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Final Report  
of the  
Defense Science Board  
1988 Summer Study on

**The Defense Industrial and  
Technology Base**

December 1988



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Volume II

Subgroup Appendices

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## PREFACE

This volume of the report of the 1988 Defense Science Board Summer Study on the Defense Industrial and Technology Base is comprised of the individual reports of each subgroup which considered a part of the overall issue. These reports represent the distillation of the information gathered by the subgroup and its recommendations to the full task force. These reports and the materials listed in the bibliography provide the factual basis for the conclusions presented in the final report of the 1988 Defense Science Board Summer Study on the Defense Industrial and Technology Base, Volume I.

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## I.

# Globalization of the Defense Industrial Base

## EXECUTIVE SUMMARY

The globalization of the Defense Industrial Base may be categorized in two dimensions, both of which address the technical and operational aspects of foreign dependency.

The first dimension encompasses "fielded" systems, products and technologies, including those under development, for which technology has been specified. This category includes major upgrades as well as programs currently in or beyond engineering development, systems currently deployed or in reserve forces, and associated spares. In addition, it includes general stockpiles of critical materials and other items which could support surge or mobilization.

In general, technology associated with this category is tightly focused and involves specific products and features from a small number of suppliers. In dealing with the foreign dependency of fielded systems, the underlying premise is to isolate vulnerabilities and incorporate a "buffer" of stock into the inventory. This buffer is envisioned to extend approximately 18 months, allowing the development of alternative approaches in case of supply interruption.

The second dimension is comprised of forward-looking concepts, systems and technologies extending over the next 10 to 20 years. It encompasses all technology within the Technology Base, including portions of earlier generations of a technology which have been applied to existing programs. Most of the so-called "dual use" technologies which have broad industry consequences fall into this category.

The "U.S. Industrial Base Dependency/Vulnerability," a report by the Mobilization Concepts Development Center, provides a sound basis for treating vulnerability beyond dependence, particularly, for the fielded systems dimension.

The report also suggests there may be means for "designing out vulnerability to foreign sources" in both dimensions at costs much lower than those required for broad maintenance of domestic

defense capability. For purposes of initial discussion, "designing out vulnerability" is viewed as providing an approximate 18-month window during which an alternative solution to any existing vulnerability may be developed.

In the forward-looking category, this task can be addressed in a well-paced, well-defined manner. For field systems and systems in development, the task is more complex, but potentially very attractive.

Each of these two dimensions must be considered in light of a range of possible "war scenarios." For purposes of this study, scenarios involving massive nuclear exchange and individual incidents of terrorism have been deemed "special case" scenarios, and have not been specifically addressed.

More appropriate to this study is the range of conditions exemplified by the Korean War, Berlin Blockade, Viet Nam, and the various Middle East conflicts, which represent the majority of possible relevant scenarios.

Critical technologies must be considered in each category even though the fielded case, in most instances, is a specific part in a particular product or system. The fielded case will concentrate on eliminating these single sources which could be vulnerable in a time of crisis. The forward-looking dimension deals primarily with the concern arising from loss of a secure domestic industry base in a particular technology for economic reasons.

A list of pertinent critical technologies has been compiled from several sources, and includes many which are associated directly with defense needs, cited as industrial priorities and subject to export controls. The list is shown in Figure I-1. Review of these critical technologies reveals that the solid-state devices or semiconductors, including micro- and millimeter wave and optoelectronics, and computing or information processing equipment are far and away the highest priority.

<u>Defense Emphasis</u>	<u>Industry Emphasis</u>
Electro-Optics and Sensing	Instrumentation and Communication
Information Processing	Computing Equipment
Micro-Electronics	Semiconductor
Materials and Structures	Materials and Processes
Energy and Propulsion	Energy and Power
Acquisition Process	Manufacturing Processes

Figure I-1. CRITICAL "CATEGORIES" OF TECHNOLOGY

Foreign dependency needs to be dealt with in both dimensions in terms of sourcing, dependence and vulnerability, with the latter representing the major consideration in a crisis. International sourcing per se is not considered a serious military problem, but over time may contribute to eroding the domestic technology base. It should be recognized that the previous rationale for off-shore sourcing to countries with lower labor rates may no longer be valid as a consideration in the future for several reasons. Of primary significance in both the computer and semiconductor technologies will be the need to utilize high degrees of automation to achieve product quality and reliability.

A less significant issue is any anticipated increase in foreign ownership of U.S. defense firms over the long term. There have been a number of domestic mergers and acquisitions involving defense and high-tech enterprises as well. Existing safeguards seem adequate to cover any realistic eventuality.

In treating the forward-looking situation, it is important to consider the changing global infrastructure which could prevail into the 21st century. Economic unification of Europe and the elimination or substantial reduction of internal trade barriers, along with the possibility of increased import restrictions, are good possibilities beginning in the early 1990s. The growth of the economies on the Pacific Rim also could generate increasing regional trade in that part of the world.

Changing internal priorities in both the Soviet Union and China are likely to open those economies to more consumer goods which, in turn, will create needs for industrial equipment. The most likely impact of these developments will be an increase in the demand for industrial and durable consumer goods that require high technology.

Since defense industries rely on similar technologies, particularly solid state, computers and software for automation, dual-use bodies of expertise can be expected to increase in the developed countries.

The forward-looking dimension contains elements of national policy which have a bearing on selecting the most attractive approach to minimizing military technology vulnerability. One of these considerations, in addition to defense, is the extent that trade, particularly exports, education and science, plays in formulating thrusts at a national level. Most of these factors have for some time been major influences in shaping policy in European and Asian countries in an integrated manner, with institutions such as MITI in Japan.

In addition to the political dimensions in the future, there is a series of considerations which transcend national boundaries

surrounding the economic sphere, including marketplaces, industrial businesses, financial institutions and people qualifications. The "Club of Rome" study, which 20 years ago foresaw a world dominated by \$100 billion corporations in the year 2000, is gaining validity. The combined role of technology and economy, which has narrowed the field of major jet engine manufacturers today to two, suggests the survival of only five "world car" companies in the future, and helps to substantiate these arguments.

The telephone and airlines industries, as additional examples, have been variously regulated on a global scale where combined economical and political factors have played joint roles, but technology is clearly emerging as a driver in those industries. Joint economic and technological factors will not be limited to manufacturing since service industries such as banking and finance are becoming increasingly automated and networked on a worldwide basis.

This study has addressed a range of potential conditions or strategies which could be employed to preserve the technological base as follows:

- 1) Status Quo - Continue to develop defense systems and invest in technologies without specific consideration for the potential vulnerability of a particular technology in a period of crisis. Some ramifications of this approach with which the U.S. would find difficulty coping include:
  - o Buy American versus cooperative development within NATO
  - o World-wide competition in microelectronic technologies
  - o Procurement practices which disincentivize new technology
  - o Technology-trade-tariff regulations which hamper exports
  - o Excessively long development cycles which delay technology
  - o Legislation and regulation limiting defense industry capital.

This option will gradually erode the domestic technology base as industry continues to rationalize sources according to peacetime conditions.

- 2) Fortress America - Presumes domestic technology is the best in the world and pays the premium to guarantee that defense capability depends solely on domestic technology. This approach does not take advantage of economies of scale in industrial businesses that are becoming increasingly important for computers and semiconductors on a world-wide basis.

Restrictions on technology disclosure to maintain such a strategy would seriously hinder industry and severely limit the contribution of universities in research. This approach has most of the drawbacks of Status Quo and also creates a difficult environment for cooperation and trade, weakening industry as a whole. Companies will atrophy in attempting to uniquely serve defense, deteriorating into arsenals of marginal economic viability and, ultimately, stagnating.

- 3) Buy from the World - Can seriously lessen technological superiority that underpins deterrent defense posture by spreading defense investment in science and technology too widely. Subjects military posture to commercial criteria with differing priorities of performance and cost that will ultimately make technology available to adversaries. Will create situations where defense posture is hostage to strategies of countries that find it in their interest to dominate key technologies without concern for cost, per se, but for some greater national interest.

This summary of globalization of the defense industrial base reflects a range of considerations that is governed primarily by the scope of "technology in the modern global equation." Technology constitutes a multi-faceted ingredient in this equation -- from the function of technological superiority as a national security foundation to the role of technology as the fuel of industrial growth and the key catalyst of productivity which buttresses standards of living.

#### BACKGROUND

In order to deal effectively with the issue of Globalization of the Defense Industrial Base, it is important to define first what the defense industrial base is and what it is not.

From a military and industrial standpoint, the question has both technical and operational dimensions. Militarily, the defense industrial base has a forward-looking component that continues to improve the technology upon which our national deterrent depends. In addition, there is a fielded component which must be maintained in a state of readiness and be continuously upgraded to satisfy our deterrent and warfighting capability. The primary concern is the condition under which the defense industrial base

must respond to a military need and the differential impact of various responses on industry components.

The defense industrial base is a special subset of total industry which supports both the military needs and the "free marketplace" on an increasingly world-wide basis. With the exception of arsenals and, to some extent, major shipyards, the military needs of the U.S. are satisfied within the industrial base. An important benefit of this symbiotic relationship between the military and industry is that U.S. defense spending, at approximately 5% of the GNP, is significantly lower than that of our major adversary. It also should be recognized that U.S. allies take a much more integrated view of their industrial and defense policies, including the emphasis placed on exports.

Other by-products of embedding defense technology in industry include economies of scale with industrial users, joint military and industrial sponsorship of research, and increased interdependence on world sources of technology. Costs alone, without concern for availability of the incentivized technology that is developed for industrial and commercial applications, make some level of interdependence a reasonable risk. Examples of defense interdependency, both with domestic industry and global sources is shown in Figure I-2 where the extensiveness of these relations is sufficient to suggest that accommodation by the defense industry is a practical approach.

TECHNOLOGY & INDUSTRY	DEFENSE	DOMESTIC	EUROPE	JAPAN	OTHER
ELECTRO-OPTICAL & MICROWAVE	DOO INITIATIVES in MMIC & IRPA	COMMUNICATIONS and FIBER OPTIC THRUST	SOME MICROWAVE & EO TECHNOLOGY	TELEVISION & GaAs TECHNOLOGY	SOVIET UNION HAS SHOWN INTEREST
SEMICONDUCTOR & PACKAGING	VHSIC INITIATIVE & GaAs FOUNDRIES	ASICs, SEMATECH & MCC CONSORTIUMS	COMPUTATION MAINLY CENTERED ON BEAT IBM	DOMINATE PACKAGING AUTOMATION FACTOR	SOURCING ASSEMBLY TO LOW COST LABOR
COMMUNICATION & COMPUTATION	STRATEGIC COMPUTING INITIATIVE & MCCR	PROLIFERATING LANs & PC APPLICATIONS	COMMUNICATION SYSTEM & EQUIPMENT HERITAGE	BUILDING UNIVERSITY INFRASTRUCTURE	WILL DEPEND on DEVELOPED NATIONS
INFORMATION & SOFTWARE	Ada, STARS PROGRAM, C3I DEVELOPMENTS	SOFTWARE INDUSTRY & WORKSTATIONS	CAPABILITY AVAILABLE BUT ACTION UNCLEAR	CHARACTER LIMITING, BUT SYMBOLIC THRUST?	DATA ENTRY BEING DONE IN CARIBBEAN
PLATFORMS & PROPULSION	A-TECH SUBMARINE & STEALTH AIRCRAFT	AIRFRAME & ENGINE are WORLD STANDARD	AIRCRAFT & ENGINE CONSORTIUMS, SHIPS	AUTOMOTIVE LEADER, LICENSING AIRCRAFT	SHIPBUILDING MOVING TO TOP THIRD WORLD
ENGINEERED MATERIALS	SUBSTITUTION for COST & PERFORMANCE	CHEMICAL & METAL EXPLORATION	ENERGY COSTS LIMITS CHEMICAL INDUSTRY	ENERGY COST DRIVING OUT PRIMARY METALS	THRUST IN PRIMARY METALS, PARLAY?
ENERGY & NUCLEAR RELATED	WEAPON & PROPULSION IMPROVEMENTS	REGULATION LIMITS DEVELOPMENT	FRENCH ELECTRICITY GOAL - ALL NUCLEAR	SOURCING TECHNOLOGY from UNITED STATES	STAG HAS INTEREST IN THIRD WORLD
AGRICULTURE & RAW MATERIALS	PETROLEUM and KEY MATERIAL DEPENDENT	PETROLEUM and AGRICULTURE RICH	PETROLEUM and RAW MATERIAL LIMITED	AGRICULTURE and PETROLEUM LIMITED	RAW MATERIALS ARE MAINLY COMMODITIES

Figure I-2. Interdependency Factors

There may even be an argument that both availability and affordability of the fielded military inventory can specifically benefit by interdependency on world-wide sources. This concept would probably require a somewhat more comprehensive approach to system design, with greater transparency of the microelectronics and software in particular.

Within this framework, it may also be possible to achieve both high performance and reduced performance export designs based on the same platform. It is even conceivable that "plug compatible" upgrades could be incorporated into fielded inventory using latest available technology in the limit. As microelectronics continue toward expanded use of ASICs to improve performance and reduce costs, it may become increasingly attractive to "design for upgrading." Similar reasoning in software could make it possible to build the necessary technology export controls in code directly.

An underlying premise of this study is that the United States has and will continue a strong dependence on technology as a part of its national strategy of deterrence. No argument is made that this is an exclusive dependence, but it is recognized that deterrence is strongly dependent on fielded capability. Fielded "quality" is a consideration and the Strategic Defense Initiative (SDI) is cited specifically as an example of a technological threat prior to fielding. Further, inability to translate technological accomplishments rapidly from laboratory to military inventory is cited as a distinct shortcoming. This suggests that any foreign dependency should be examined across the whole life-cycle from basic research and initial technology demonstration through engineering development and, ultimately, to deployed inventory.

The spectrum of conditions under which foreign dependency should be considered range from a global nuclear exchange, the Southeast Asia conflict, the Berlin airlift, the significant upgrading of the past 10 years, to potential future arms reduction. The levels of responses to these conditions range from complete replacement of the total military inventory, which might take several years and several trillion dollars, to removal of foreign nationals from technical graduate schools. A "middle ground" alternative might involve a complete buyout of the microelectronic memory devices for the Trident X missile fire control. One conclusion which emerges from this analysis is that the extreme conditions of a massive nuclear war and a complete replacement of the total fielded military inventory represent very extreme cases of interdependence.

Figure I-3, which provides examples of critical defense technologies and delineates the primary military contributions and the roles of non-military industry in their application, demonstrates the key role played by manufacturing. Manufacturing is

important in terms of economy of scale, process control and automation as well as technology itself as it relates to processes and materials. From the standpoint of interdependency, industries such as steel, in which very strong competition exists throughout the world, have found recently that "downsizing" and introduction of new technology can create a turnaround. This may suggest that a national strategy and policy which reinforces interdependency while preserving our domestic sources as one leg of "dual or multiple sources" has additional leverage.

TECHNOLOGY	DEFENSE FUNCTION	INDUSTRY FUNCTIONS
NUCLEAR	• PROPULSION, WEAPONRY, SAFING, ARMING AND FUZING	• NUCLEAR POWER GENERATION, SPACE EXPLORATION
MICROWAVE	• RADAR, ELECTRONIC WARFARE AND COMMUNICATIONS	• COMMUNICATION, TELEVISION, AIR TRAFFIC CONTROL
E-OPTICS	• INFRARED DETECTORS, LASERS, NETWORKS AND DISPLAYS	• FIBER OPTIC COMMUNICATION, COPIERS, TELEVISION
MICRO-E	• A/D DEVICES, LOGIC, MEMORIES, AND MICROPROCESSORS	• COMPUTERS, DIGITAL PROCESSING, DIGITAL CONTROLLERS
COMPUTERS	• MINI-COMPUTERS, MAINFRAMES, AND SUPERCOMPUTERS	• SCIENTIFIC COMPUTING, EMBEDDED MICROPROCESSORS
PROCESSING	• DISTRIBUTED AND PARALLEL SIGNAL, DATA AND IMAGERY	• PLANT CONTROL, COMMUNICATION NETWORKS, SWITCHING
SOFTWARE	• ENVIRONMENTS, LANGUAGES, LIBRARIES, AND EMBEDDED	• BANKING, BUSINESS, AUTOMATION, DATA PROCESSING
PACKAGING	• MICRO-E, POWER, M-WAVE, E-OPTICAL DEVICE ASSEMBLY	• MICROELECTRONIC EQUIPMENT, INDUSTRIAL ELECTRONICS
MATERIALS	• METALS, POLYMERS, FIBERS, CERAMICS AND COMPOSITES	• PRIMARY METALS, ALLOYS, PLASTICS, CERAMICS
MANUFACTURING	• PROCESSES, PROCUREMENT, ASSEMBLY, QUALITY AND TEST	• CASTING, FORMING, ROLLING, EXTRUDING, COATING
AUTOMOTIVE	• TANKS, LIGHT ARMOR, PERSONNEL CARRIERS, TRUCKS	• AUTOMOBILES, TRUCKS, BUSES, TRACTORS, EARTH MOVERS
AIRCRAFT	• FIGHTERS, BOMBERS, PATROL, HELICOPTERS, TRAINING	• COMMERCIAL AIRLINERS, BUSINESS AIRCRAFT, HELICOPTERS
SHIPLYARDS	• CARRIERS, COMBATANTS, SUBMARINES, TENDERS, OVERHAUL	• COASTAL SHIPS, OCEAN RIGS, FERRIES, FISHING VESSELS
MACHINE TOOLS	• AMMUNITION, WEAPONS, GUNS, AIRCRAFT, JET ENGINES	• MACHINING, CUTTING, SHAPING, ATTACHING, MILLING
SEMICONDUCTOR	• DEVICES, PROCESSES, SIMULATIONS, WORK STATIONS	• WAFER and MASK MAKING, DIE ATTACH, PACKAGING, CAD
CAE, CAM, CAL	• CA DESIGN, DEVELOPMENT, MANUFACTURING AND LOGISTICS	• ARCHITECTURE, CONFIGURATION CONTROL, ANALYSIS TOOLS

Figure I-3. Critical Technologies vs. Critical Industries

With the possible exception of shipyards where the majority of domestic capacity for large vessels and submarines is devoted to naval shipbuilding and overhaul, there do not appear to be industries the defense establishment depends upon which are likely to be abandoned in the foreseeable future. There may be some erosion of the electronics industry through the very substantial inroads made by Japan in consumer electronics, but there is no real evidence that any capability which is critical to national defense would be lost. For some time, studies have shown that productivity and, in turn, standard of living, are very favorably affected by technology, providing an additional incentive to exploit the national technology base on as broad a front as possible.

This study has been undertaken within this framework and includes supporting treatments of war scenarios, defense ownership, critical technologies and industries, international trade and cooperation, development of systems, stockpiles and reserves.

## SUMMARY FINDINGS

### War Scenarios

A range of scenarios predicated on existing Defense Guidance were reviewed as a framework for assessing military impact of globalization. These scenarios were developed originally to define the basis for sustaining in the short term, mobilizing for a global war in the long term, and surging to deal with smaller conflicts. The range of conflicts and conditions indicates that surge could involve levels of production up to half that of full mobilization. Use of war reserves in support of very low levels of conflict further suggests that flexibility in production rate, probably coupled to inventory capability, should be a long-range objective. Over this span of conditions, "invulnerability" to sources of equipment or parts and materials is essential.

The Graduated Mobilization Response concept provides a framework within which globalization can be examined from an operational standpoint supported by the CINC-designated critical items. Consideration should be given to a spectrum of vulnerabilities that transcends stockpiles, war reserves, sustaining, surge and mobilization and deals with "inventory" necessary for operations. Use of an inventory concept will better deal with the time and vulnerability dimensions as well as provide a strong basis for production planning. In the longer term, an integrated approach to development and deployment can provide the basis for significant cycle reduction and can strengthen efforts in streamlining.

### Foreign Investment

A comprehensive review was made of foreign investment in defense companies, including outright purchase and a range of lesser involvements. The various legislative and regulatory safeguards were examined and found generally to furnish good protection. From the standpoint of the defense industry, foreign investment in the U.S. shows no particular pattern and seems more to reflect individual company strategies. The majority of direct investments in the U.S. as a whole are being made by our trading partners, with Japan the recent overall leader, and the United Kingdom the leader in defense-related acquisitions. There is evidence that defense companies in allied countries are forming joint ventures to improve access to the U.S. defense market through NATO involvement.

In general, review of foreign investment shows little direct concern with respect to the defense industry, but when coupled to sourcing by domestic manufacturers, the pattern is less favorable. A U.S. culture of "essential isolation" from export and, in turn, producer orientation that governs national policy of our trading partners ultimately will erode our domestic capacity. Foreign investment in the U.S. has historically followed and continues to follow our broader economic policies that provide good, safe capital returns that are not burdened by domestic producer investment.

As long as the economies of scale of the U.S. market allow this luxury and our tax laws foster consumption, this "perpetual machine" will run, although it ages every year. Imagine what a fraction of the U.S. national debt invested in productive capacity would do for both industry and defense.

#### Critical Technologies

Critical technologies were reviewed from a variety of standpoints with particular emphasis on military needs and areas of competition with the U.S.S.R. A significant emphasis was found on technologies which provide or preclude "sensing" capability as shown in Figure I-4 where virtually the entire electromagnetic spectrum is identified. Strongly coupled to sensing are those technologies dealing with signal-image-data processing that translate detected data into useful information. This further translates into computers, software and digital electronics that, when coupled to "man" as shown in Figure I-5, make up the "smart brain" of defense systems. The whole arena of man-machine and display also is seen evolving toward various subsets of artificial intelligence and, ultimately, robotics in military applications.

The Militarily Critical Technologies List was found as the best overall measure of criticality, primarily through the emphasis on manufacturing. Most other defense listings of technologies emphasize performance and product at the expense of process of building or even designing, and overlook general industry knowhow.

A potentially critical example of this coupling in the future could be sensing as a military need and instrumentation as critical to industry automation. Both gallium arsenide semiconductors and 10+ bit A/D converters could each be critical to either military sensor suites or industrial process control. The ability to apply technologies also is as important, albeit different, from maintaining a "second to none" enabling technology base.

COMMUNICATIONS	SIGNAL & DATA PROCESSING	MECHANICAL SYSTEMS & MATERIALS	WEAPONS
SURVIVABLE NETWORKS	SOFTWARE/ALGORITHM	STEEL/STOVL/VTOL TECHNOLOGY	CONVENTIONAL WEAPONS AND MUNITIONS
TELECOMMUNICATIONS	DEVELOPMENT	CONVENTIONAL WEAPONS	DIRECTED ENERGY WEAPONS (1)
BATTLEFIELD COMMUNICATIONS	COMPUTERS & SOFTWARE (3)	AERODYNAMICS (3)	DIRECTED-ENERGY TECHNOLOGY
	DISTRIBUTED INFORMATION	FLUID DYNAMICS (2)	DIRECTED ENERGY (LASERS,
MICROWAVE & OPTOELECTRONICS	PROCESSING	HYPersonic	PARTICLE BEAM, RF/RPH)
HIGH ENERGY MICROWAVE	OPTICAL INFORMATION	AEROMATERIALS	HIGH ENERGY MICROWAVE
MILLIMETER WAVE	PROCESSING	Cooling of hot structures	SHORT WAVELENGTH LASERS
NON-LINEAR OPTICS	INFORMATION PROCESSING	LARGE SPACE STRUCTURES	CONVENTIONAL WARHEADS
OPTOELECTRONICS (2)	IMAGE PROCESSING	LIGHT-WEIGHT MATERIALS	NUCLEAR WARHEADS
ELECTRO-OPTICS	LOW-COST HI-SPEED MILITARY	ULTRALIGHT AIRPLANES	CHEMICAL WEAPONS
RADAR SENSOR	COMPUTER TECHNOLOGY	SATELLITE PRODUCTION	EXPLOSIVES (2)
PHOTONICS	SIGNAL PROCESSING (3)	SURVIVABILITY	GUIDED WEAPONS
ACOUSTICS	SUPERCOMPUTERS	SMART SKINS	ANTIPROTON TECHNOLOGY
INFRARED		ROBOTICS	PLASMA DEFENSE TECHNOLOGY
OPTICS		HIGH TEMPERATURE MATERIALS	LIQUID PROPELLANT WEAPONS
		ULTRASTRUCTURED MATERIALS	ELECTRIC PROPULSION WEAPON
SENSING	ARTIFICIAL INTELLIGENCE	Liquid propellants	
INFRARED SURVEILLANCE	ARTIFICIAL INTELLIGENCE (6)	ELECTRIC PROPULSION	
HIGH DENSITY MONOLITHIC	KNOWLEDGE BASED SYSTEMS	ARMOUR MATERIALS	
FOCAL PLANE ARRAYS	MACHINE INTELLIGENCE (3)	ADVANCED MATERIALS (3)	
MILLIMETER WAVE SENSORS	ROBOTIC TELEPRESENCE	COMPOSITE MATERIALS (2)	
MULTI-ELEMENT ARRAYS	"BRILLIANT" WEAPONS	ADVANCED COMPOSITES	
FULL-SPECTRUM, ULTRA-	ROBOTICS (3)	MATERIALS (2)	
RESOLUTION SENSORS	VIRTUAL MAN-MACHINE		
ADAPTIVE CONTROL OF	INTERACTION		
ULTRALARGE ARRAYS	AIRCRAFT COMBAT MISSION		
SOLID-STATE ANTENNAE ARRAYS	ENHANCEMENT		
LASER RANGING & TARGETING			
ACTIVE & PASSIVE SONAR	NAVIGATION, GUIDANCE & CONTROL	MAN-MACHINE & DISPLAYS	ENERGY, POWER AND PROPULSION
IN. JAMMING	GUIDANCE & NAVIGATION (2)	BIOTECHNOLOGY (3)	INTERNAL COMBUSTION ENGINE
ELECTRO-OPTIC SENSOR	BRILLIANT GUIDANCE (2)	LIFE SCIENCES	HIGH-ENERGY-DENSITY
NON-LINEAR OPTICS	SMART WEAPONS	UMAN FACTORS	PROPELLANT
SPACE BASED RADAR	"FLY-BY-WIRE/LIGHT" CONTROL	MICRO-PROCESSOR BASED	PROPELLATION SYSTEMS (2)
RADAR SENSOR (2)	ADAPTIVE CONTROL OF	PERSONAL LEARNING AIDS	HIGH PERFORMANCE TURBINE
SMART SKINS	ULTRALARGE ARRAYS	PILOT HEAD-UP DISPLAYS	ENGINE (2)
SENSORS (4)		RAPIDLY RECONFIGURABLE	COMBINED-CYCLE ENGINE
		CREW STATION	PARTICLE-BEAM NUCLEAR
SUBMARINE DETECTION	SOFTWARE	DISPLAY TECHNIQUES	PROPULSION
BROAD SPECTRUM	COMPUTERS & SOFTWARE (3)	PROTECTION LETHALITY (2)	LIQUID PROPELLANT WEAPONS
SIGNATURE CONTROL	SOFTWARE DEVELOPMENT		ELECTRIC PROPULSION WEAPON
ADVANCED DECEPTION	ULTRAHIGH SOFTWARE QUALITY	SYSTEM/PRODUCT DESIGN	SPACE NUCLEAR POWER
LOW OBSERVABLES	AND PRODUCTIVITY	UNIFIED LIFE CYCLE	SPACE POWER
SIGNATURE REDUCTION (2)		ENGINEERING	POWER SOURCES
STEALTH (3)	MICROELECTRONICS & PACKAGING	SMART BUILD-IN TEST (BIT)	
	MICROELECTRONICS (3)	STEEL/STOVL/VTOL TECHNOLOGY	
( ) MULTIPLE LIST ENTRIES	ELECTRONIC MATERIALS AND	AIRCRAFT & HELICOPTERS	
	IC MANUFACTURING	GUIDED WEAPONS & TORPEDOES	
	WAFER LEVEL UNION	ARMORED VEHICLES	
	of DEVICES	OBSERVABLES TECHNOLOGY (7)	
	ACOUSTIC CHARGE TRANSPORT	SPACE TECHNOLOGY (2)	
	FAIL SAFE, FAULT TOLERANT		
	ELECTRONICS (2)		
	ULTRARELIABLE ELECTRONIC		
	SYSTEMS		
	RADIATION HARDENED		
	ELECTRONICS		
	SUPERCONDUCTOR MATERIALS		
	SURVIVABILITY		
	VLSI CIRCUITS & SYSTEMS (2)		
	VHSIC		

Figure I-4. Technology Listing

## TECHNOLOGY CATEGORIZATION

- CONSISTENT WITH SYSTEM DESIGN

MOST AEROSPACE SYSTEMS HAVE A SIMILAR DESIGN CONCEPT  
AND GROUPS OF PERVERSIVE TECHNOLOGIES

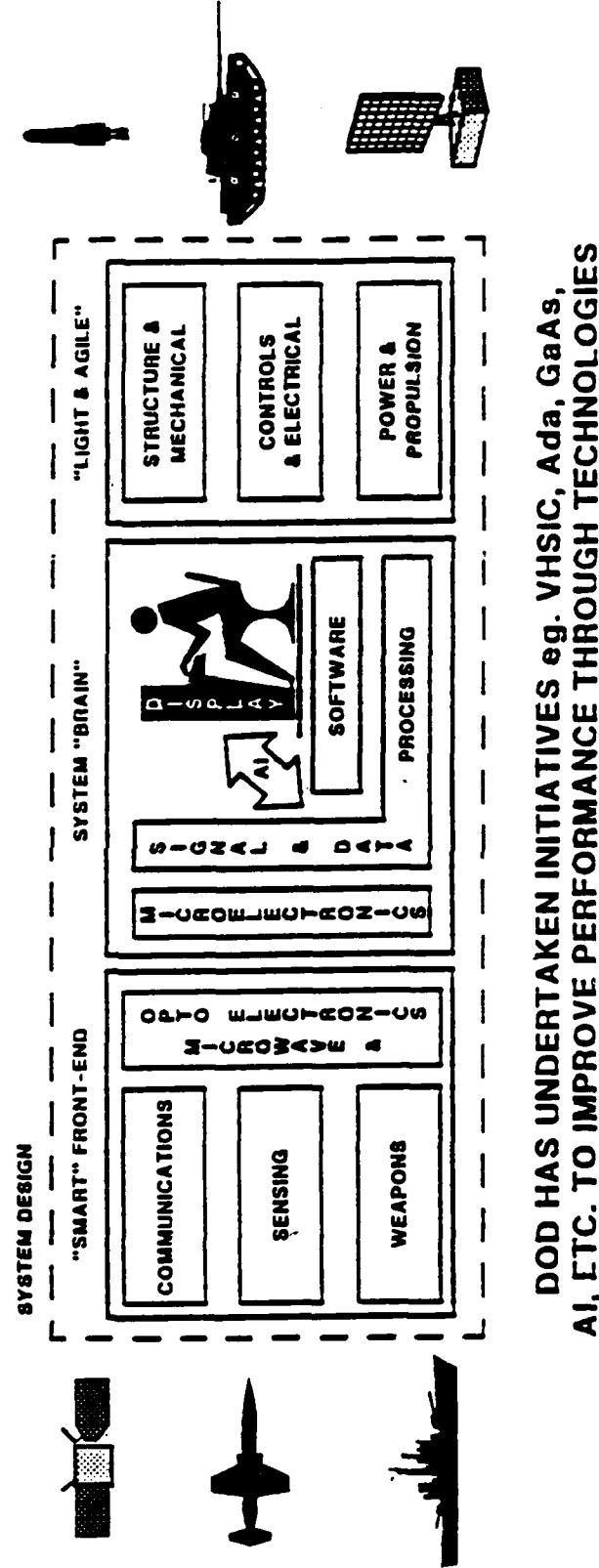


FIGURE I-5

### International Trade

Although total defense spending worldwide exceeds \$1 trillion annually, total international arms transfers are declining from a 1984 peak of approximately \$50 billion. The major arms exporters are the U.S.S.R. and the U.S., each holding approximately 30 percent of the export market, and France with 10 percent. U.S. international arms sales are expected to rise from the current \$10 billion level and approach the \$15 billion threshold in the future, driven primarily by the Nunn Amendment which is designed to promote cooperative R&D. A prior Emerging Technology Initiative in NATO has defined over 150 projects of interest.

The field of prospective participants in Nunn Amendment programs was confined initially to NATO countries, but was extended in 1987 to include Japan, Korea and Australia of the Pacific Rim, and Egypt and Israel in the Middle East. The INF Treaty also is expected to drive the cooperative R&D within NATO, particularly for conventional weapons, C<sup>3</sup>I and surveillance systems.

Potentially more significant to globalization than defense sales are the associated offsets, sourcing by defense and dual-use industry, and commercial aerospace sales. The net balance of trade of the latter is expected to reach \$17 billion in 1988 which compares with a negative differential in electronic sales between the U.S. and Japan of approximately \$20 billion per year.

U.S. electronic component imports, primarily from Japan, now exceed \$10 billion, with semiconductors amounting to approximately 75 percent of the total. A significant consideration in the future will be the capitalization for the increasing automation necessary to obtain high quality electronic and machine parts with banking strength moving to the Far East.

On the horizon, greater acceptance of commercial standards, particularly in electronics and probably in high use machine parts, will further intensify global defense dependence.

### Systems Acquisition

Review of the acquisition process covered analysis of the Technology Base including major technology initiatives; e.g., VHSIC, Strategic Computing in relation to industry IR&D. From the standpoint of foreign dependency, more emphasis on transitioning of Tech Base and Initiatives into manufacturing would serve to make domestic suppliers, particularly at the lower levels of defense procurement, more competitive. The most significant technology areas in defense and general industry are semiconductor related in terms of product, but manufacturing processes were found to be of even greater importance to industry as a whole. This impacts strongly computer systems and equipment where a recent survey of "high tech" leaders across a range of

industries were shown to be concentrating on computerizing of internal operating processes. Additionally, there was substantial evidence that a major thrust of industry is toward simplifying designs and reducing cycle times of processes similar to the DoD Streamlining Initiative. Continued emphasis in this area with increased attention to technology alternatives should favor more application-specific design and, hence, domestic sources.

An area closely related to acquisition is the whole spectrum of logistics and support systems that contribute under crisis conditions to the operability and sustainability of weaponry. The myriad of stockpiles, spares, mods, war reserves and prepositioned supplies in addition to front line inventory must be considered in relation to foreign dependency. Of particular concern from the standpoint of potentially high use and attrition during conflict are guided missiles and munitions, tactical aircraft and combat weapons which are becoming increasingly electronics-intensive. This observation, when coupled to the need for greater transition of initiatives to manufacturing, suggests that a prioritization based on expected crisis use has merit. Equivalently, within the acquisition process, a couple of milestone checks on foreign dependency and buffering or providing North American alternative sources seems very reasonable. There may be some real opportunities to take advantage of current industry "cycle and simplify" emphasis to generate a win-win for industry as a whole.

#### RECOMMENDATIONS

The following recommendations have been developed from review of the work by the Globalization subgroup and over 100 previous studies on this subject. Although emphasis is on limited conflict scenarios, these recommendations will enhance our posture under more severe conditions. Furthermore, they can be undertaken within the normal framework of procurement and should not await a crisis. The majority of any cost associated with these recommendations really represents a "cash flow" since buffer stocks created ultimately will be consumed in future production.

##### RECOMMENDATION 1.

###### Recommendation 1A.

For the current (fielded) dimension, develop (via existing or prospective ongoing contracts) an 18-month supply of foreign vulnerability items and capability for 1.5 times normal production rate down to the fourth/fifth tier.

- STEP 1. Conduct "6-month" studies to assess costs of the following:
- 1) Precision Guided Missiles
  - 2) Tactical Aircraft
  - 3) Armored Vehicles
  - 4) Space Assets
- STEP 2. Under Secretary of Defense for Acquisition to develop procurement methodology to invoke via prime contractors.
- o Satisfies the following war scenarios requiring surge capability:
    - Replacement of equipment/supplies used to support friendly nation in short intense conflict or long, drawn-out guerilla threat with periodic intense conflict.
    - Restore readiness in the theaters by replacing stocks consumed by the U.S. in a broad range of operations.
    - Option of expeditiously increasing war reserve stocks or unit equipment fill as a reaction to strategic warning.
  - o This use of surge capability also is the essence of the Graduated Mobilization Response concept being implemented throughout the Federal Government by direction of the National Security Council.
  - o Projected to be very economical (\$12 to \$15 million for Precision Guided Missiles).
  - o Can be implemented within current DoD procurement structure.
  - o No unneeded material is created. It can be rolled into production.
  - o SECDEF can test the efficacy by tasking the system to produce for an 18-month period at surge (1.5 normal production) rates.

Foreign Vulnerability Item is defined as any item upon which the U.S. is solely dependent on a foreign supplier and for which there are no immediate North American alternatives. Surge Capability is defined as providing equipment and supplies at a rate 1.5 times normal production within a period of 12 to 18 months.

### Recommendation 1A. Discussion

The recommendations to create buffer stocks for current equipment and systems and to design out vulnerability to foreign dependency in the future will involve a significant fraction of the military inventory. Expendable items such as precision guided missiles, munitions, sonobuoys, combat systems/vehicles and tactical aircraft, all of which can experience high rates of attrition, are of particular concern. Tactical communications as well as related space systems also warrant consideration on the basis that any vulnerability to effective military operations can and probably would be exploited. Similarly, spares or parts procured to support existing inventory in the field of aircraft, missiles or combat systems could expect to be impacted. Strategic aircraft, ballistic missiles and ships also may be vulnerable to foreign dependency and should be reviewed for potential impact and corrective action as warranted.

An analysis of ongoing procurement is shown in Figure I-6 which indicates that almost half of current expenditures are potentially affected in either new equipment or spares and parts. It also should be noted that in addition to ongoing procurement, there are more than 20,000 aircraft in service, including Reserve and Guard, and several hundred thousand guided missiles and munitions. The study, U.S. Industrial Base Dependence/Vulnerability, estimates the cost of buffer stocks for precision guided munitions at \$15 million based on the ongoing procurement.

KEY TACTICAL PROCUREMENTS					
	UNITS	COST	UNITS	COST	UNITS
<b>NEW EQUIPMENT</b>					
COMBAT AIRCRAFT	704	14371	612	12758	554
TACTICAL MISSILES	30626	6046	46853	6089	48648
OTHER MUNITIONS	348460	1239	275086	1071	293541
COMBAT SYSTEMS	1659	2764	1306	2443	1282
ELECTRONIC EQUIPMENT	8442	116	10331	119	937
SONOBUOYS	440478	182	382221	185	202913
ELEC & SPACE PROGRAMS	NA	2029	NA	2333	NA
SUBTOTAL	830369	26747	717229	24958	510875
<b>MODS, SPARES &amp; PARTS</b>					
AIRCRAFT MODS	4989	3494			3734
A/C SPARES & PARTS	5088	4330			4854
MISSILE MODS	233	230			232
MSL SPARES & PARTS	584	522			598
OTHER SPARES & PARTS	800	750			700
SUBTOTAL		34441		34284	36269
<b>TOTAL PROCUREMENT</b>		<b>81517</b>		<b>81379</b>	<b>78632</b>
<b>PERCENT KEY TO TOTAL</b>		<b>47%</b>		<b>47%</b>	<b>46%</b>

Figure I-6. Key Tactical Procurements

Similar reasoning suggests that with appropriate allowance for complexity and numbers of units, the total cost for systems in procurement, including non-recurring engineering, would be well under a billion dollars. Spares and parts for other equipment and systems in service probably should await accumulation of some experience at instituting buffer stocks for ongoing system procurement.

Recommendation 1B.

For future dimension, institute a buy free world/guard vulnerability strategy since current laws and regulations on foreign ownership are generally sufficient. Seek out and take maximum advantage of symbiotic and complementary technology developments within industry. Use Conventional Defense and Streamlining Initiatives to incorporate technology alternatives and minimize vulnerabilities.

o Execute Recommendation 1A.

- Institute DoD policies to complement industry technology to achieve win-win position since commercial (not defense) will dominate U.S. long-range technology position due to economic leverage.
- Develop a per-country procurement "fairness doctrine" (do not hamper U.S. companies and commercial interests).
- Facilitate environment for industry consortia to implement cooperative approaches in critical technology areas, e.g., VHSIC.

Recommendation 1B. Discussion

Future systems and major modifications, including those not yet approved for production or having past Milestone III, should be subject to specific foreign dependency criteria and check points. It may be possible to extend provisions of the "Buy American" legislation to make an allowance for the cost of domestic alternatives to eliminate U.S. vulnerability to foreign suppliers. This approach also could have the added benefit of ensuring that use of foreign sources for performance reasons is genuine, and not simply for purposes of cost or convenience.

Introducing the concept of alternative domestic sourcing to eliminate foreign vulnerability also will incentivize defense suppliers, making them more competitive in terms of both performance and cost. The option of using buffer stocks for future systems should be retained to allow selection of the best performance option when domestic sources are not readily available.

Recommendation 1C.

Integrate space assets, and their vulnerabilities (both in a battle and foreign supply sense) into surge/mobilization considerations.

- o Replacement critical, given Soviet ASAT capability.
- o Crisis build time of replacements is 18 to 24 months. Launch vulnerability and availability also are factors.
- o In-orbit spares an option which could be implemented.

**RECOMMENDATION 2.**

Develop policies and procedures for ensuring availability and use of intelligence early warning information in support of Graduated Mobilization Response. The warning must result in a specific trigger to initiate surge or mobilization.

Recommendations 1C. and 2. Discussion

In addition to the recommendations for dealing with foreign vulnerability is the closely related issue of surge and mobilization in time of crisis. Warning also is a critical factor which the study, Graduated Mobilization Response, suggests can enhance markedly the avoidance of conflict by providing additional options with deterrent capability. Key ingredients of warning are space assets and their ground elements which, according to the "Discriminate Deterrence" report, are designed for peacetime.

A summary of possible approaches to reducing space system vulnerabilities is shown in Figure I-7. Within the space community, there is a practice of using preferred parts lists which can highlight foreign supply that is in the process of being adopted for other systems; this practice warrants endorsement. In addition to their role in terms of warning, space and national assets in general are being increasingly considered for support of tactical operations which makes any potential vulnerability of further concern.

The revised national space policy of February 1988 specifically states: "Survivability and endurance of national security space systems, including all necessary systems elements, will be pursued commensurate with their planned use in crisis and conflict, with the threat, and with the availability of other assets to perform the mission." Within the Graduated Mobilization Response, there also are several observations and recommendations dealing with the transition from peace to war which relate to warning.

• MILITARY REQUIRES "ASSURED ACCESS TO SPACE"

- PRESIDENTIAL DIRECTIVE, FEBRUARY 1988

• MILITARY USES OF SPACE ARE INCREASINGLY "BUILT IN" TO OPERATIONS PLANS IN A RANGE OF SCENARIOS

• OPTIONS FOR REDUCING VULNERABILITIES:

LAUNCH	SPACECRAFT	C2
• ADDED LAUNCH SITES	• HARDENED COMPONENTS & DEFENSIVE SHIELDS	• MULTIPLE SITES
• VARIETY OF LAUNCH VEHICLES	• REDUCE OBSERVABLES & USE OF DECOYS	• DISTRIBUTED PROCESS AND CONTROL
• LAUNCH PARTNERS - FRANCE, etc.	• ATTACK WARNING & MANEUVERING	• MOBILE/SURVIVABLE
• LAUNCH ON DEMAND - ICBM, SUBMARINE, etc.	• ON-ORBIT OR LAUNCH ON DEMAND SPARES	• SDI ELEMENT USAGE

Figure I-7. Military Use of Space

The spectrum of transition is well-depicted in Figures I-8 and I-9 from the GMR study which indicates the importance of specific criteria to define increasing levels of potential conflict. Recent study has described the need for integrated architectures to handle the spectrum of peace-to-war situations as urgent, but fraught with bureaucratic "turf battles." When this situation is overlayed by potential elements of Space Defense and coupled into Allied forces, the magnitude of the management issues is very real and must be addressed.

The whole spectrum of potential world conditions which can be realistically expected to occur over the next 10 to 20 years and govern the development and deployment of military capability needs review. Emphasis such as CINC-critical items, streamlining acquisition, industry cycle reductions, product simplification and the rapid turnover of technology are making time a greater factor. There exists a significant need to deal with this rapidly changing and increasingly complex environment in real time by at least quantifying the framework to some extent. The criteria defining any change in situation, which may change the relative importance of various factors, need more attention. A vital element in design of future military systems will be treatment of vulnerability under peacetime conditions such as foreign sourcing, logistic system flaws, technology obsolescence, education of foreign nationals or illegal technology export.

Planning and Preparation	Crisis Management			National Emergency/War	
Level 6	5	4	3	2	1
Deliberate planning & investment	Crisis planning, preparation & options  PATTERN OF THREAT TO U.S. INTERESTS IDENTIFIED			Mobilization of the economy  (DIRECT CHALLENGE TO U.S. NATIONAL SECURITY)	
Independent actions & information exchange, as appropriate	Progressively increasing coordination & NSC direction			NSC or other centralized control	

Source: MCDC "GMR," 1988

Figure I-8. GMR Stages

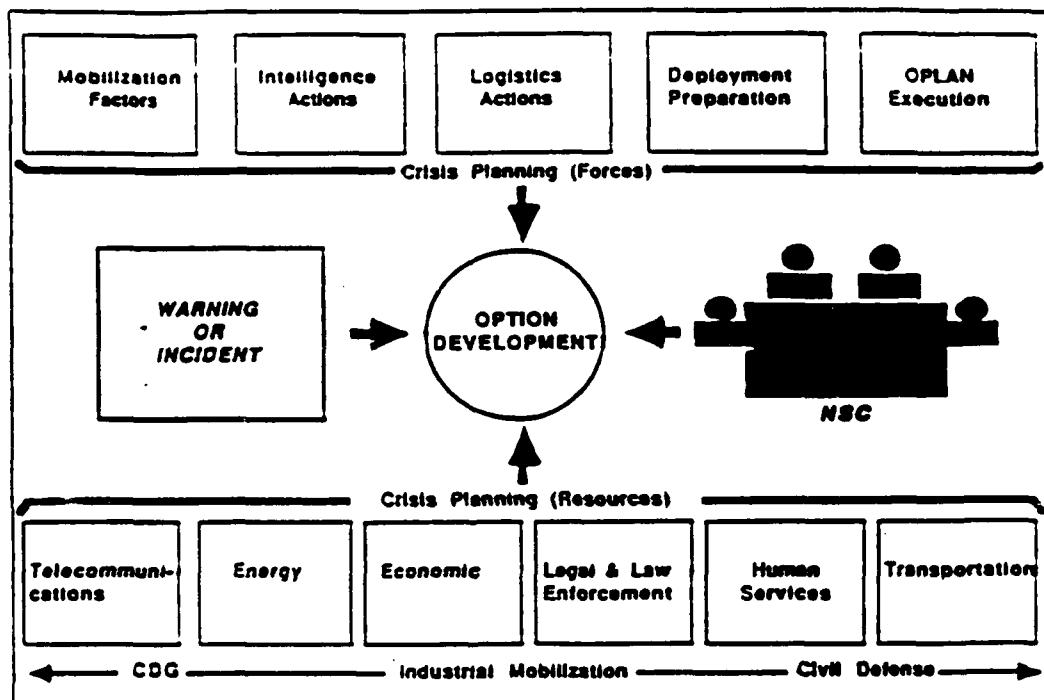


Figure I-9. Graduated Mobilization Response Actions

### **RECOMMENDATION 3.**

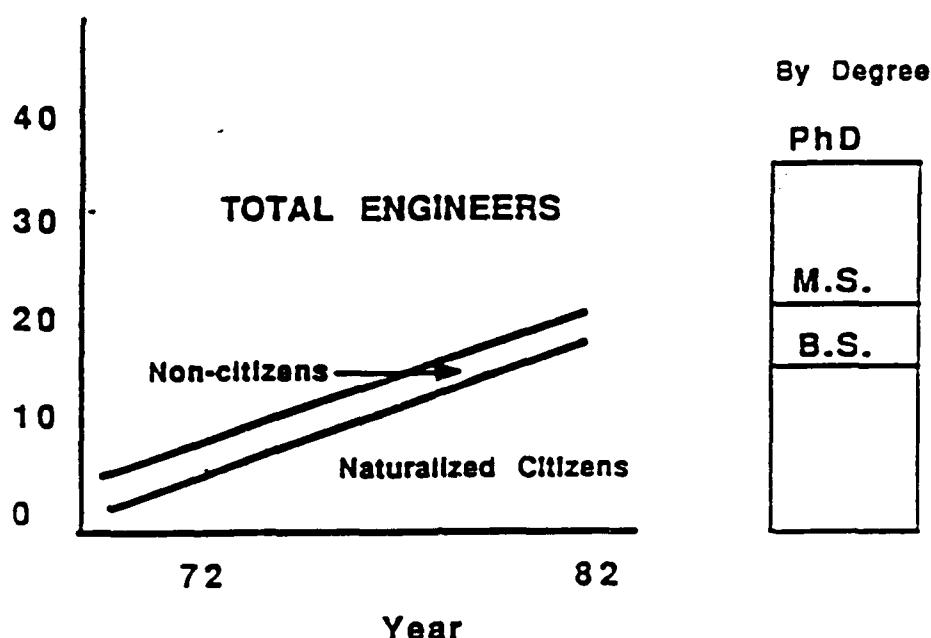
#### **Strengthen educational dimension of technology strategy for defense.**

- o Support existing policies:
  - Modest growth and 10-year stability of IR&D.
  - Provide for Tech Base and Initiatives transition.
- o Add educational policy:
  - A new GI Bill for technical education.
  - Secondary School incentives for ROTC.
  - Primary and Secondary School science initiative.

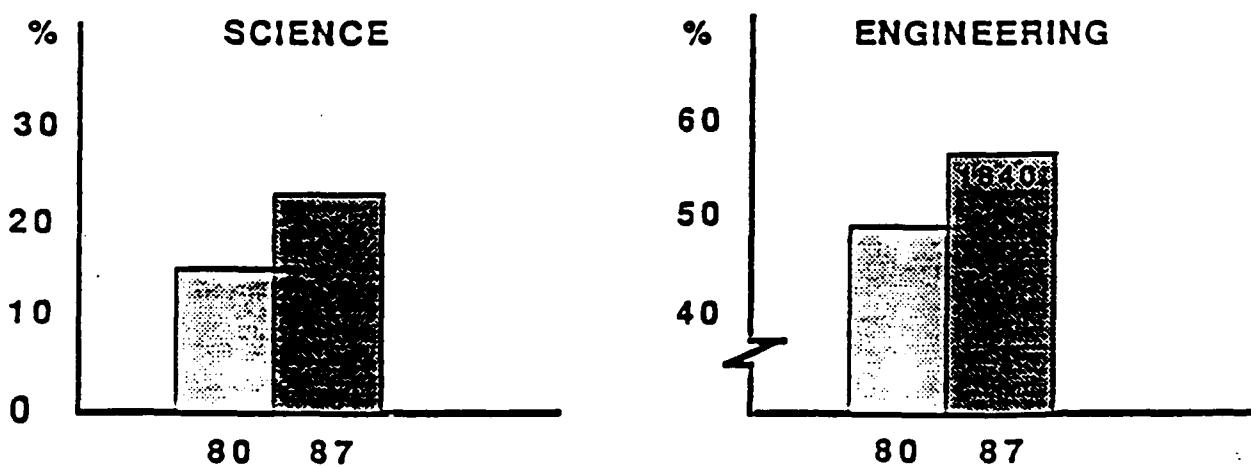
#### **Recommendation 3. Discussion**

One final area of foreign interdependency which warrants mention is that of foreign nationals in the engineering work force and particularly within graduate technical institutions. A survey of R&D directors in the industrial sector indicates a significant dependence on foreign engineers, but a minimal concern about the numbers. In fact, concerns were expressed regarding federal government regulations on employing foreign nationals and the need to understand lack of interest by native Americans in pursuing science and engineering careers. Most of the survey respondents traced the lack of interest in science and engineering careers to a weakness in U.S. primary and secondary education system. It will be increasingly more difficult to convince industry not to use foreign sources when its design work is being done by foreign nationals or foreign-born citizens.

Looking to the future, there is a steady trend upward in foreign engineers as shown in Figure I-10, and particularly in terms of advanced degrees. A recent survey showed some 36% of foreign-born engineers are involved in R&D, while only 22% of native-born engineers are similarly employed. The growth in doctorate degrees awarded foreign-born students, as shown in Figure I-11, for both science and engineering can expect to further increase this R&D dependence. There also have been concerns expressed within the academic community that foreign-born students, over time, could have an adverse impact on the quality of engineering education. These concerns focus on possible shortcomings in language of foreign-born teachers and on scientific versus practical emphasis due to cultural background.



**Figure I-10. Foreign-Born Engineers**



**Figure I-11. Foreign-Born Doctorates Awarded**

Approximately one-third of the current engineering graduate school population is foreign-born and emanates from countries considered non-industrialized by Western standards. Since two out of every three U.S. engineering graduates are foreign-born, any effort to redress dependency must include a component that somehow increases domestic interest in science and education as a real career and not just a ticket to sell technical products.

#### RECOMMENDATIONS

The DSB Subgroup on Globalization makes the following three specific recommendations in the context of the following:

- o Our belief that the infrastructure of both the commercial and defense industrial base will be increasingly global.
- o There is little evidence that foreign ownership of defense constitutes an immediate threat . . . however, the DoD should continue to monitor that threat and, conversely, ensure that ownership (by USA companies) of off-shore defense firms is not precluded.
- o There is a variety of laws and entities which ensure responsible foreign ownership (of U.S. defense firms).
- o A much easier flow of technology, especially in the commercial sense, needs to be facilitated by DoD (in order for America's total industrial base to participate, unhampered, in a global economy).
- o The DoD should reject both the status quo and Fortress America concepts as unrealistic (in light of evolving globalization).
- o Our belief, buttressed by the MCDC PGM study (only \$15M required to guard foreign vulnerability on a variety of PGMs) that we can provide significant protection for minimal dollars . . . that these dollars are of a "cash flow" variety . . . and that the recommendation can be tested for efficacy and cost on a frequent basis.
- o Other factors which are included in our overall secondary recommendation for a defense industrial policy.

The reduction of all these considerations to the specific three recommendations is driven by a desire to advise steps which can make a significant difference, given the current budget environment.

The DSB Subgroup on Globalization of the Defense Industrial Base recommends the following:

- 1) Develop (1.5 x rate, 18 months) buffer stocks of defense consumables which consist of foreign vulnerability components.
  - o Studies shall be conducted in the areas of PGMs, Tactical Aircraft, Armored Vehicles, Space Assets, C<sup>3</sup>I assets, HBC defenses. The outputs of the studies shall be quantities and costs.
  - o The USD(A) shall implement the procurement of the identified components, and shall test the efficiency of the system by selecting one area to test on 18-month centers.
  - o The responsible study direction and implementation authority shall be the USD(A) via the new position of the Deputy Under Secretary of Defense for Production Base and International Technology.
- 2) The DoD shall develop a specific set of trigger thresholds, developed from all source warnings, which will trigger the use of all or part of the buffer stocks of foreign vulnerability components.
- 3) The DoD shall take the lead in developing a national educational program to ensure long-term industrial base superiority. This shall be accomplished in cooperation with the Departments of Education and Commerce and include, at a minimum:
  - o Secondary school incentives for technical "junior ROTC"
  - o GI Bill for undergraduate support
  - o 6.1, IR&D, and Technology Base initiatives funds for graduate technical education.

#### Secondary Recommendation

It is important that the DoD consider development of its own "Plan for Industry" having elements of:

- o Buy free world/guard vulnerability policy (REC. 1)
- o National technical educational programs (REC. 3)
- o Identification of critical technologies and a long-range strategy for each

- o Encouragement of industry cooperative efforts in these critical technologies
- o A better defined, freer policy on technology export
- o A country-by-country Memorandum of Understanding (MOU) (level playing field) defense ownership/trade/tariff/offsets)
- o Domestic policies which encourage technological leadership
- o Continued facilitation of "Nunn Amendment" concepts for NATO and facilitation of the "Quayle Amendment" for Southeast Asia/Japan.



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## **II.**

# **Nation of Japan's Industrial and Technology Direction**

### **REPORT TO DSB**

A comprehensive study of the U.S. "Defense Industrial and Technology Base" would favorably consider many of the government and industrial policies practiced by Japan today; as would each nation that has a global goal of leadership. As prescribed by their constitution, Japan's leadership direction is not military but rather industrial, with a very strong emerging technology emphasis.

This report was specially prepared for the DSB by experienced professionals based in Japan. A high standard of objectivity was followed by using the latest available factual data, as well as historic data for trends. Although various subjective assessments could be drawn, this report remains neutral, with such assessments made to the DSB at large.

A single recommendation is put forth: namely, to increase the focus on Japan and to improve the formal acquisition of future Japanese technology through cooperative agreements.

### **REPRESENTATIVE SOURCES**

Each chart in this report that references projected or actual data contains a reference source.

The following table lists 20 of the most important sources, ranging from U.S. sources such as the National Science Board to Japanese executive government policy documents such as "Maekawa Report" 1987 and "MITI Report on Information Industry Vision Toward 2000," to Japanese government agency reports such as "Statistics Bureau - 1987" and "Science and Engineering White Paper - Agency of Science and Technology, 1987," to periodicals such as The Oriental Economist.

TABLE II-1  
REPRESENTATIVE SOURCES

1. Science & Engineering Indicators - 1987, National Science Board (U.S.).
2. Science & Engineering White Paper - 1987, Agency of Science & Technology (Japan).
3. Patent Agency Annual Report, May 11, 1987.
4. Patent Agency Annual Report, May 11, 1988.
5. Report on the Survey of Research & Development - 1987, Statistics Bureau (SORI-FU).
6. Report on Economy Structure Change for International Cooperation - April 7, 1986 (MAEKAWA Report).
7. Report by Economy Structure Change/Special Panel Council (Economy Council, Special Panel - New MAEKAWA Report), April 23, 1987.
8. Report on Information Industry Vision Toward 2000 - MITI Info 2000 (Industry Structure Council - Long-Term Vision Panel), June 19, 1987.
9. Defense White Paper - 1987, September 10, 1987.
10. MITI - Challenge Toward 21st Century (Industry Strategy Laboratory), June 14, 1988.
11. Technology Future of Japan - Biggest Project 100 (Industry Research Company), September 15, 1987.
12. Japan Influence in America, International Business Week, July 11, 1988.
13. Japan Economic Yearbook - 1981-1982, The Oriental Economist, August 1987.
14. Japan Company Handbook - 1st Half 1986, The Oriental Economist, Summer 1988.
15. KAISHA - The Japanese Corporation - 1987 (James C. Abegglen and George Stalk, Jr. - Tuttle).
16. Total Vision - Industry Structure Change - January 1988 (Industry Structure Council, Planning Panel).
17. Space Development Handbook - 1987, KEIDAN-REN, Federation of Economic Organizations Space Development Promotion Committee.
18. Industrial Groupings in Japan, 1986/1987 Edition, Dodwell Marketing Consultants.
19. 21st Century Energy Vision - November 1987, MITI, Agency of Resources & Energy.
20. 21st Century Bio-Industry Vision - December 1984, MITI, Department of Infrastructure Industry.

## REPORT SCOPE

In addition to the statistical and policy references, interviews were held with MITI, and with military and government personnel from the U.S. Embassy in Tokyo. The last section of this report addresses what government-to-government agreements are available for technology transfer.

This report is more than data references in terms of the judgments necessary to integrate the data into a systematic perspective of past, present and future. The report does not, however, promote advocacy for specific changes to the U.S. government process or organization. The report stresses trends rather than exactness from statistical data. The industrial development of the other Pacific Rim countries -- the Newly Industrialized Countries (NIC) -- is only briefly examined from an extension of Japan's policy, not from a country-by-country perspective.

Japan's industrial and technology progress is impressive and persuasive in suggesting that nations with aspirations for economic and industrial growth must have a similar commitment to long-range, sophisticated strategic planning closely linked with a strong government guidance and a cooperative private sector/industrial relationship.

This presentation provides an overview of R&D activities in Japan and the role government plays in establishing a structure and environment conducive to the development of key technologies.

### Environment

We will focus on the key comparisons between Japan and the U.S., with emphasis on trade, technology and R&D. Examples in the information industry will be used, since most of our expertise is in this area. A view of R&D activities will attempt to describe the relative value of these activities with respect to GNP, population, and roles. A view of the resultant patent application process as a measure of output and productivity will be provided to show the capacity of Japanese R&D relative to the other developed nations.

### Role of Government

The Japanese government has played a substantial role in the development of the computer and electronics industries in Japan in the past 30 years. We will use this section as a vehicle to describe the relationship between industry and government agencies and the relative roles they play in the continuing evolution of the Japanese domestic and international economy.

### Information Industry

A review of the influence of the Ministry of International Trade and Industry (MITI) on the electronics and computer industry and a view of this industry in the year 2000 as forecast by key government and industry leaders. We will focus on key projects and programs and their potential impact on the world-wide industry.

### Technology Trends

Key memory and logic trends and the resultant need for development of new manufacturing technologies needed to continue the rapid improvements in price, performance, size, and capacity will be discussed. We will review the increasing synergy of the consumer electronics, telecommunications, and data processing industries.

## EXECUTIVE SUMMARY

The growth rate of R&D funding in Japan exceeds that of any Western country and the increase has produced the highest rate of patent applications worldwide and a leadership position in U.S. patents. This high degree of R&D is focused on the commercial sector in Japan and thus is effective in producing commercially viable products.

The role of government in Japan is significant in that MITI provides strong guidance to industry and the public along with a consensus approach to defining the current and future structure of industry. The government also provides funding and protection when necessary. The government does not exercise a great deal of control and is not a primary source of funding.

Industry, government, and academia are considered partners in establishing direction and priorities for the key industries while sharing risk in large projects. This consensus approach to policy is strengthened by a supportive media that allows the national agenda to be clearly and consistently conveyed to the public and the international business community.

Synergy of technologies from the telecommunications, data processing, and consumer electronics industries will allow the Japanese to use the leverage of high-volume, low-cost consumer technologies in lowering the cost and expanding the functions of systems in the other two industries. Japan is the home of the only companies in the world that actively participate in all three of these emerging sectors.

The various reports on the Vision of the Year 2000 by MITI state that the technologies of the "Information Society" will be the bedrock on which the new international Japan's economy will be built. If the recent advances in technology can be sustained, the Japanese industries are well positioned to be a major factor in influencing the technologies of the world in the next decade.

#### TECHNOLOGY TRENDS - OBSERVATIONS

- o High Growth Rate of R&D
  - Industry Funded
  - Low Government/Defense Content
  - High Development Productivity
- o Government Provides Strong Guidance
  - Economic Structure
  - Technology Investments
  - Domestic Economy Stimuli
- o Promotion of "National Agenda"
  - Government/Industry/Academia Cooperation
  - Risk Sharing
  - Media Support
  - Commercial Competition
- o Synergy of Key Sectors
  - Consumer Electronics
  - Information Processing
  - Telecommunications
- o "Information Society" will be Fundamental to Japan's Future GNP Growth

## ENVIRONMENT -- DEMOGRAPHICS

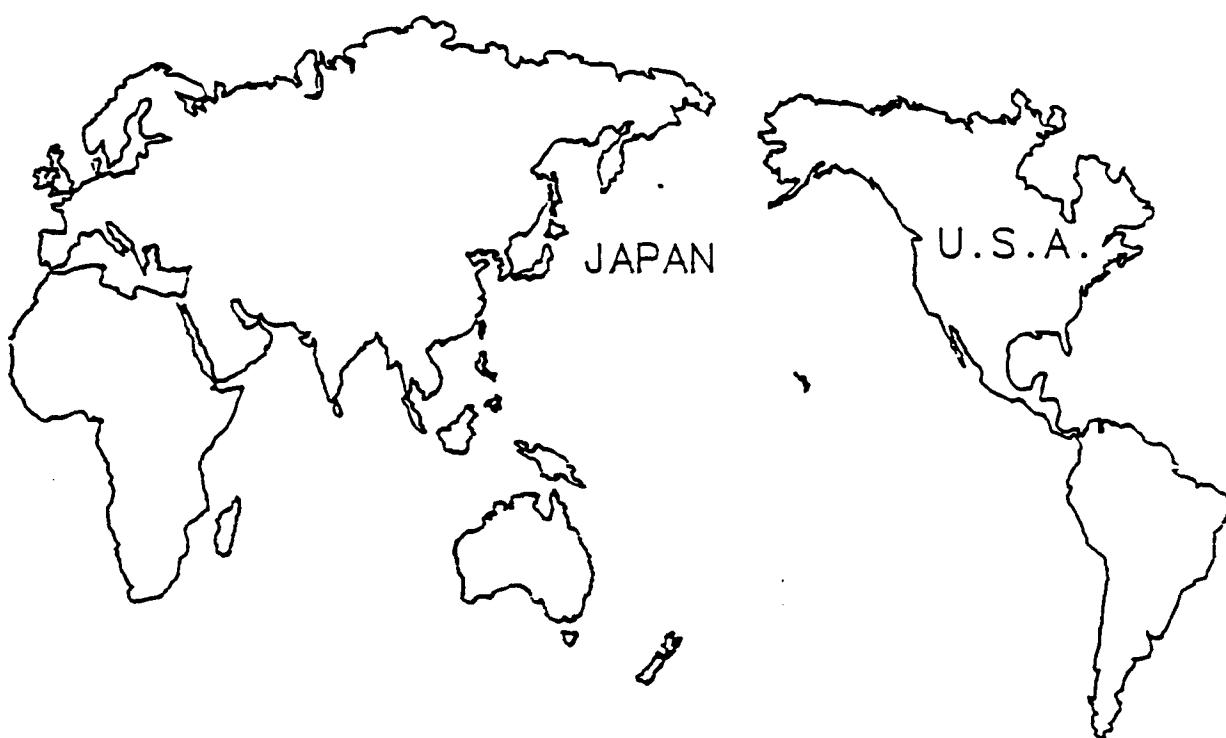
The size of Japan's population is approximately half that of the U.S., occupying an island nation that is only 4% the size of the U.S. land mass. This density is compounded by the fact that only about 20% of the total land area in Japan is suitable for living and less than 17% is suitable for agriculture. The main problem is that a great deal of the land that could support agriculture is used to live on. This lack of physical resource is clear to all in Japan and has a significant influence on the national concern with protecting their domestic agriculture industry.

The lack of natural resources, coupled with the limited space, has driven Japan to develop as the manufacturing (and thus export) leader in Asia. The very positive results have led to the build-up of the financial and monetary influence of Japan as its export and domestic outputs continue to expand.

The education system of Japan has produced disproportionate numbers of technical graduates: the number of engineering graduates in Japan is nearly equal to that in the U.S. When the number of foreign-born students that receive degrees in the U.S. is taken into consideration, Japan out-produces the U.S.

Japan has long since migrated from the status of a developing country with an advantage of lower wages and standard of living. In 1987, Japan's GNP per capita exceeded that of the U.S. to become the world leader. The strength of their domestic economy is more evident when we consider that the percentage of total GNP derived from exports has dropped from 14% in 1984 to 10% in 1987. In light of the continued growth in their exports, the growth of the domestic economy is particularly impressive -- even more so in view of the fact that the continuing strength of the yen is having some limiting impact on trade.

## ENVIRONMENT - DEMOGRAPHICS



	JAPAN	U.S.A.
POPULATION (MILLION)	121	239
AREA (KM <sup>2</sup> )	377,801	9,372,614
GNP (\$B)	2,385	4,488
GNP/CAPITA (\$M)	19,711	18,778
% WORLD GNP	13	25
TOTAL TRADE VALUE (\$B)	379	677
ENGR. GRAD	71,396	77,871

SOURCE: BANK OF JAPAN, ECONOMIC STATISTICS MONTHLY,  
ECONOMIC PLANNING AGENCY

## ENVIRONMENT -- JAPAN/U.S. TRADE, 1987

As a trading partner, the U.S. is Japan's largest customer and supplier. The U.S. buys 37% of Japan's exports and supplies 21% of their imports. The U.S. is less dependent on Japan as we ship only 12% of our exports to Japan and buy 22% of our imports from the Japanese.

The Japanese have become a larger component of our agricultural trade, growing from a 14.8% share in 1980 to 23.2% in 1986. In their consumption of U.S. farm products, their total is larger than the next three countries combined.

Although transportation equipment still represents the largest single export to the U.S., electronic components and consumer electronics is increasing at a much faster rate. Even in light of the shift of lower technology products such as radios, VCRs, and electrical components to the newly industrialized economies of Taiwan, Korea, Singapore and Hong Kong, the Japanese continue to increase the value of exports. This is due in part to the continued ability of the Japanese companies to both develop follow-on technologies and to develop the market for them worldwide. This is evidenced by the shift from televisions to VCRs to video cameras to CDs, etc.

The persistent pace at which products are introduced, enhanced and replaced is unmatched in any other country. This is a base characteristic of the domestic Japanese economy and not necessarily driven by the export market.

## ENVIRONMENT -- JAPAN I/S RELATED EXPORTS

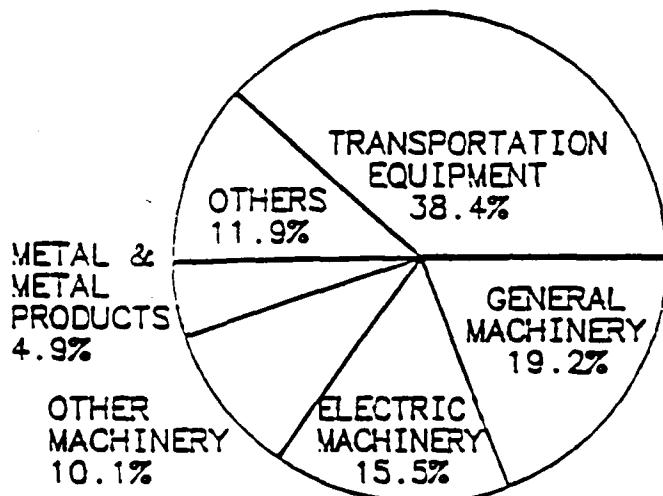
In order to better view the high growth electronics export sector, it is important to subdivide the exports into their various elements by technology. While a decade ago copier technology represented the largest part of a modest export business, the fastest growing, and today by far the largest segment is data processing. DP products and components now represent more than 50% of total exports and are growing at a rate of 50% to the U.S. and 47% to Europe. Japan's semiconductor (IC) exports to the Asia Pacific countries are more than those of the rest of the world combined. This is particularly important when one considers that the Asian countries are including these components in products that are eventually exported to the U.S. and Europe.

The export numbers represent customs clearance value only and do not accurately represent the market or end user value of these technologies. Also not evident from this chart is the extent to which products assembled and sold in the U.S. and Europe are in fact dependent on technologies from Japan. A good example is the

approximately \$7 billion worth of DP exports to the U.S. which could have a market value of from \$15 billion to \$20 billion.

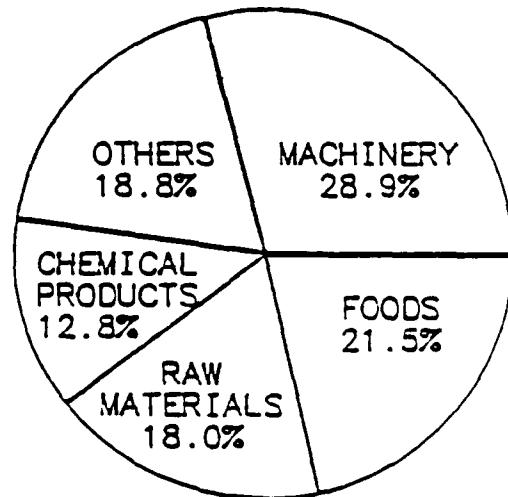
## ENVIRONMENT - JAPAN / U.S. TRADE, 1987

TOTAL \$83.6B



JAPAN'S EXPORTS TO U.S.

TOTAL \$31.4B



JAPAN'S IMPORTS FROM U.S.

SOURCE : CUSTOMS CLEARANCE STATISTICS

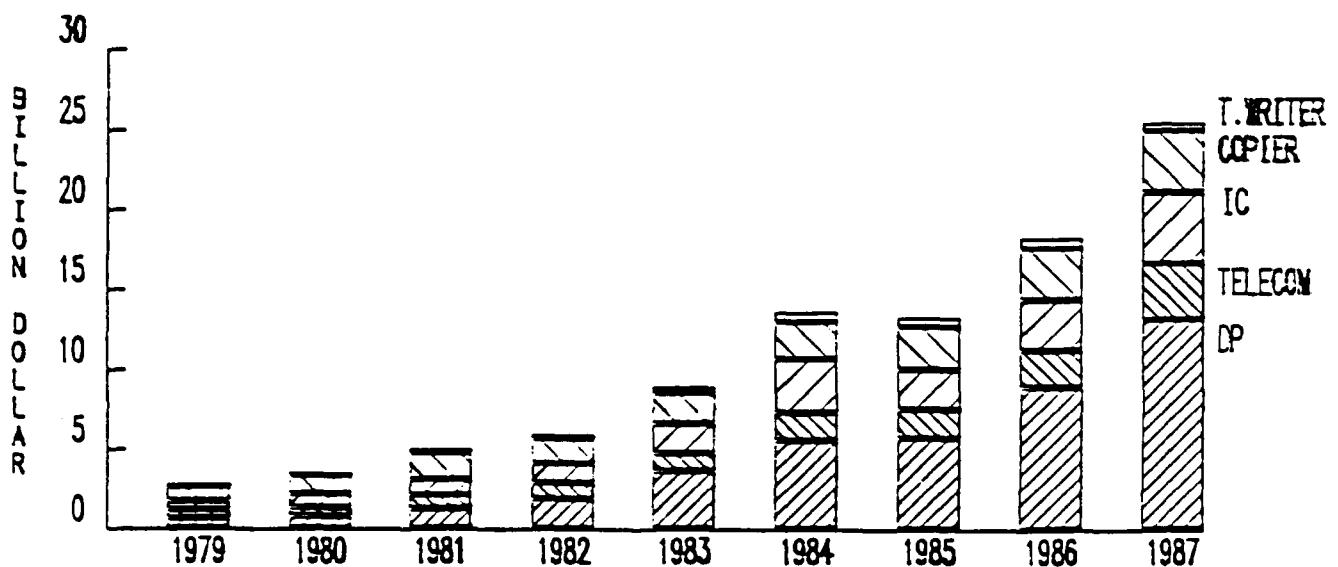
JAPAN'S INDUSTRIAL AND TECHNOLOGY DIRECTION

Japan has also used its technology as a means of influencing its Asian neighbors. Major companies can offer a great deal to the developing countries of the world by providing telecommunications, electrical transmission, and computer equipment along with the software and installation expertise needed to build their infrastructure. When coupled with Official Development Assistance (ODA) funds from the Japanese Government, it is evident that the de facto standard for products and technology is being established by the Japanese in Asia. Since a condition of the ODA grants and loans is that the capital equipment procured be built in Japan, the Japanese products get to be the standard very quickly.

The Japanese have been instrumental in pressing for international standards such as OSI and ISDN as well as influencing the computer character set standards being set for the countries whose languages need to be represented by double byte characters instead of the western single byte versions.

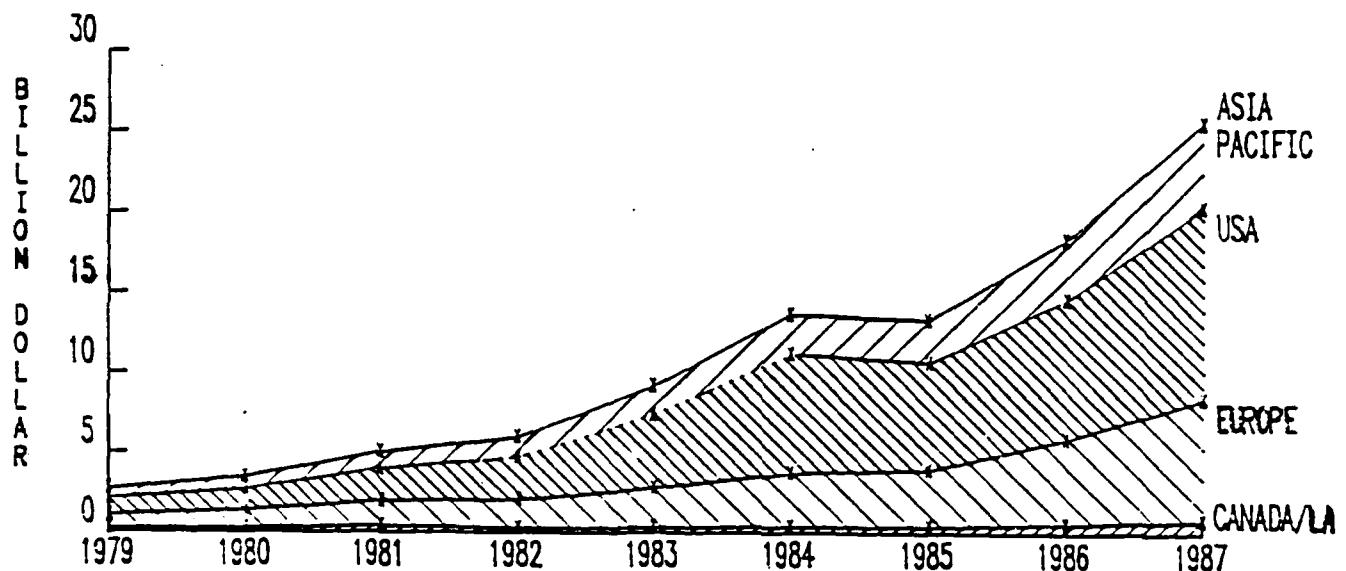
#### ENVIRONMENT - JAPAN I/S RELATED EXPORTS

#### BY PRODUCT



ENVIRONMENT - JAPAN I/S RELATED EXPORTS (Cont'd)

BY REGION



AVERAGE EXCHANGE RATE

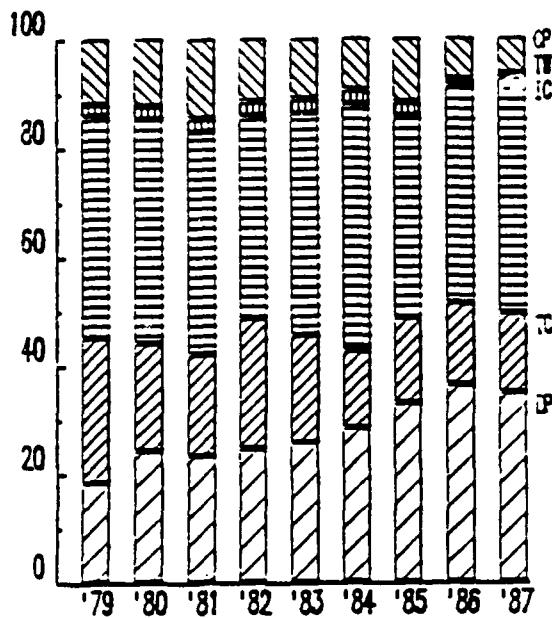
217      230      221      248      238      238      243      173      138

SOURCE: JAPAN EXPORTS & IMPORTS BY JAPAN TARIFF ASSOCIATION

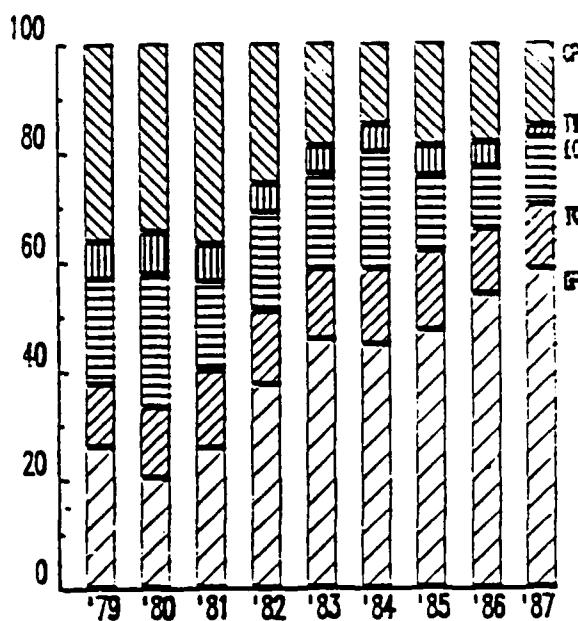
## ENVIRONMENT - I/S RELATED EXPORTS BY GEOGRAPHY

### SHARES BY PRODUCT

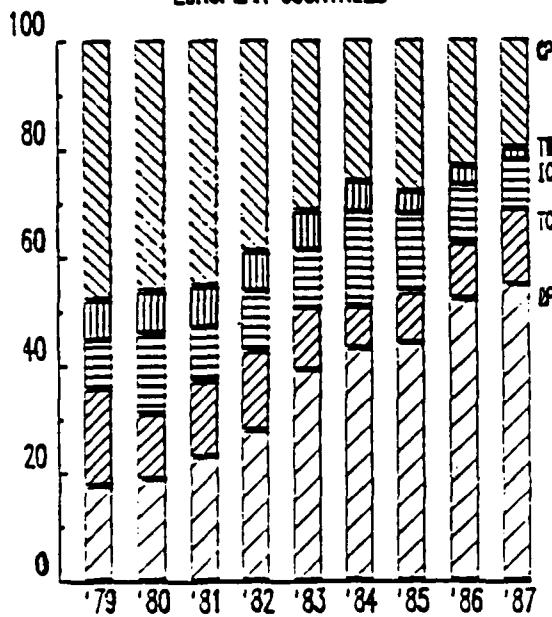
#### ASIA PACIFIC COUNTRIES



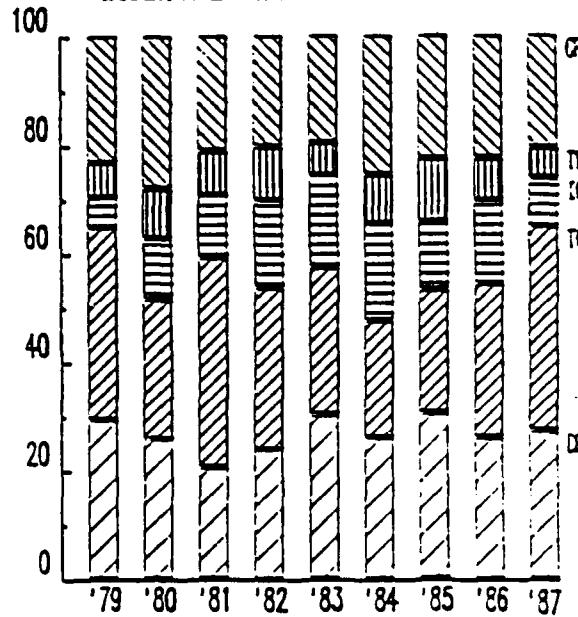
#### UNITED STATES



#### EUROPEAN COUNTRIES



#### CANADA & LATIN AMERICAN COUNTRIES

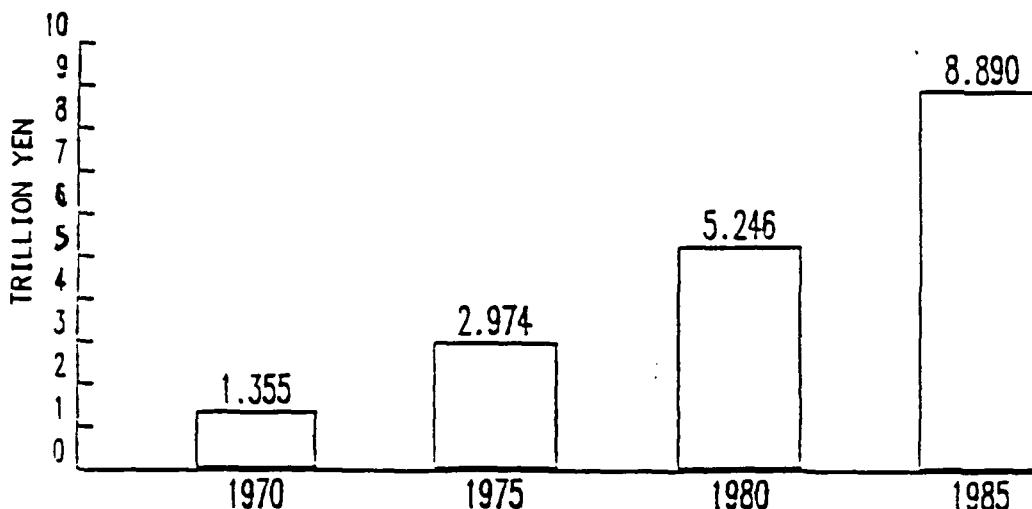


SOURCE: JAPAN EXPORTS & IMPORTS BY JAPAN TARIFF ASSOCIATION

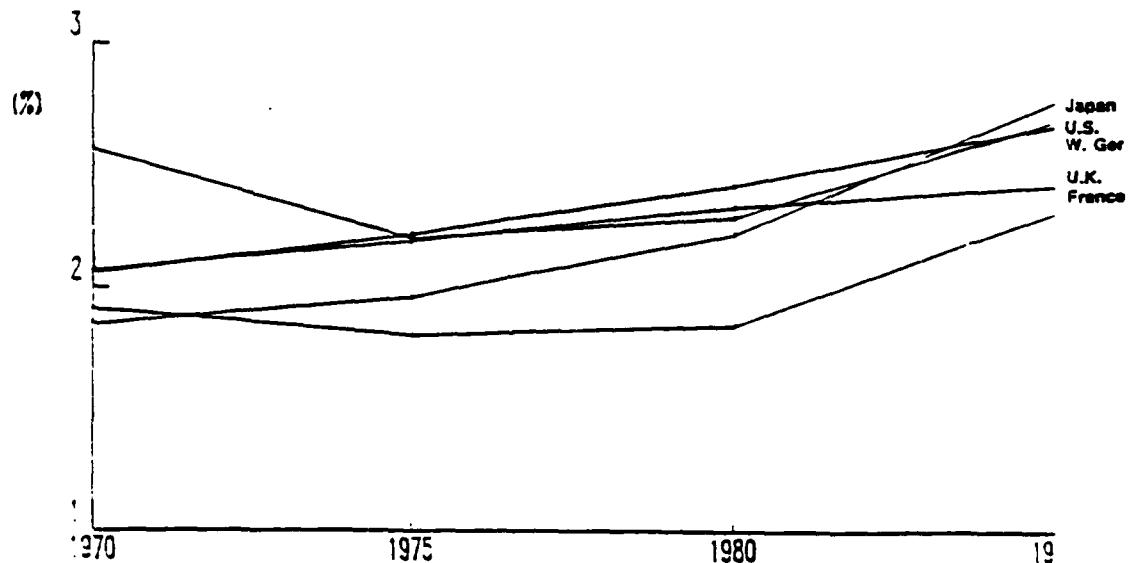
### ENVIRONMENT --- R&D INVESTMENT

Total R&D expenditures have been increasing faster in Japan than in any developed country and have even increased relative to the total GNP. This is significant when the actual GNP has grown to be the largest per capita in the world. As a percent of GNP, R&D grew 26% between 1970 and 1985 from 2.2% to 2.8%.

### JAPAN R&D INVESTMENT



### R&D/GNP



SOURCE: SCIENCE & ENGINEERING INDICATORS, 1987  
NATIONAL SCIENCE BOARD

## ENVIRONMENT — R&D SOURCE/PERFORMANCE

The significant difference between R&D activities in the U.S. and Japan is the source of funding. Although the government provides guidance and seed funds for selected projects, nearly three-fourths of the total R&D funding comes from the industrial sector.

This commercial control tends to focus the funds and efforts on projects and areas that have either the potential for commercial return or a well-defined development requirement.

The institutions that perform R&D activities are distributed much like those in the U.S. The main difference is that the R&D efforts in Japan are more self-sustaining in that they return to industry the means to expand and differentiate themselves and their products from the international competition.

JAPAN (¥8.890B) - 1985 FY

US (\$117B) - 1986

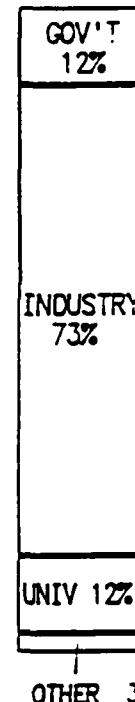
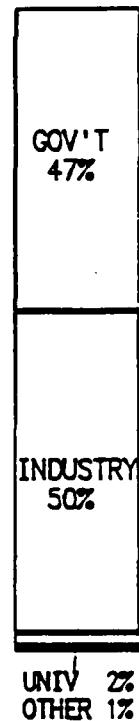
FUNDING  
SOURCE

PERFORM



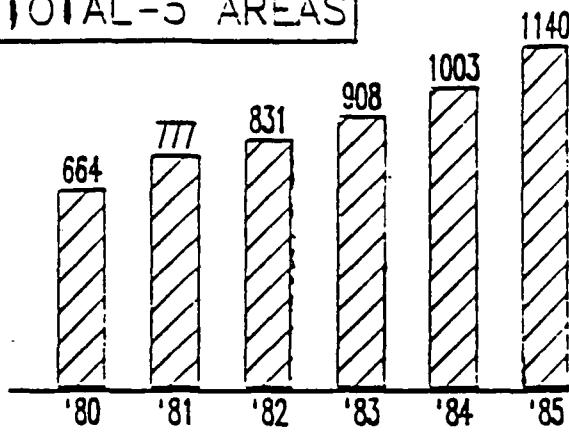
FUNDING  
SOURCE

PERFORM

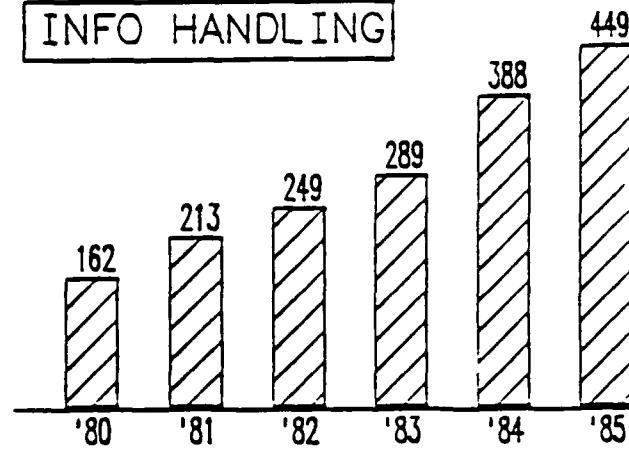


# ENVIRONMENT - R&D BY INDUSTRY

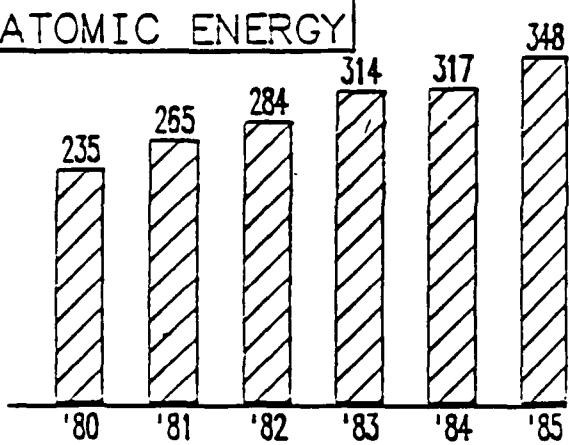
**TOTAL - 5 AREAS**



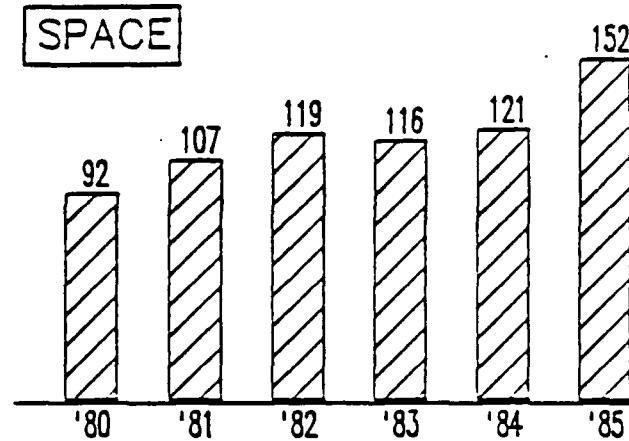
**INFO HANDLING**



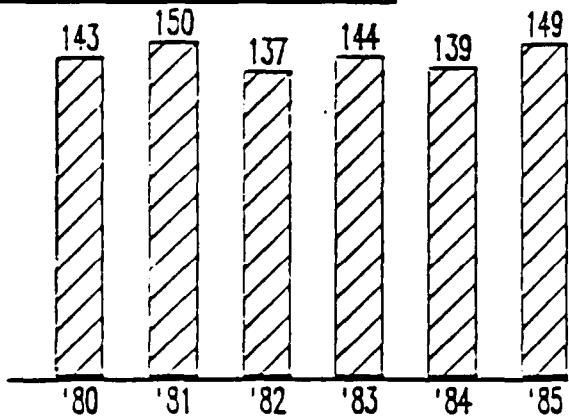
**ATOMIC ENERGY**



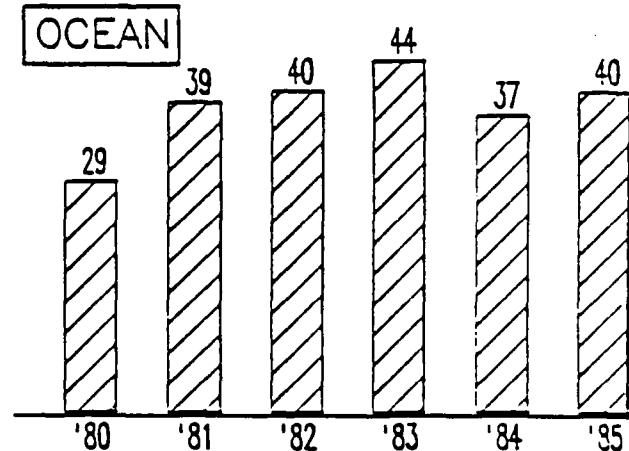
**SPACE**



**ENVIRONMENT PROTECTION**



**OCEAN**



SOURCE: JAPAN SCIENCE & TECHNOLOGY AGENCY

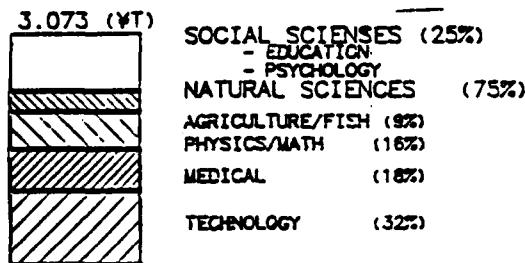
(B¥)

## ENVIRONMENT -- JAPAN R&D INVESTMENT, 1986

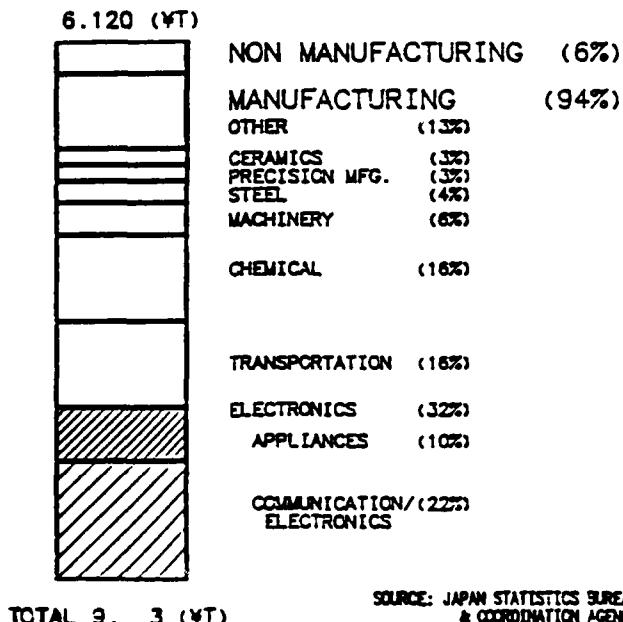
A closer look at the distribution of the funds provided for R&D shows that both primary sources place the largest emphasis on the technologies that are essential for continued participation in the key sectors of the future. Although the government takes the natural role in funding issues necessary for the growth and support of their maturing population, the first order of funding is in technology. The unwritten role that the industrial sector plays in providing for the public welfare is part of the reason that a relatively small portion of publicly funded R&D is for public issues.

The large proportion of funding for telecommunications and electronics research serves as a forecast for the key industries of the future. It is clear that the R&D funding is focused on the elements that will sustain the technology edge they have built in the last two decades.

### UNIVERSITY/GOVERNMENT/PRIVATE LABORATORIES



### COMMERCIAL



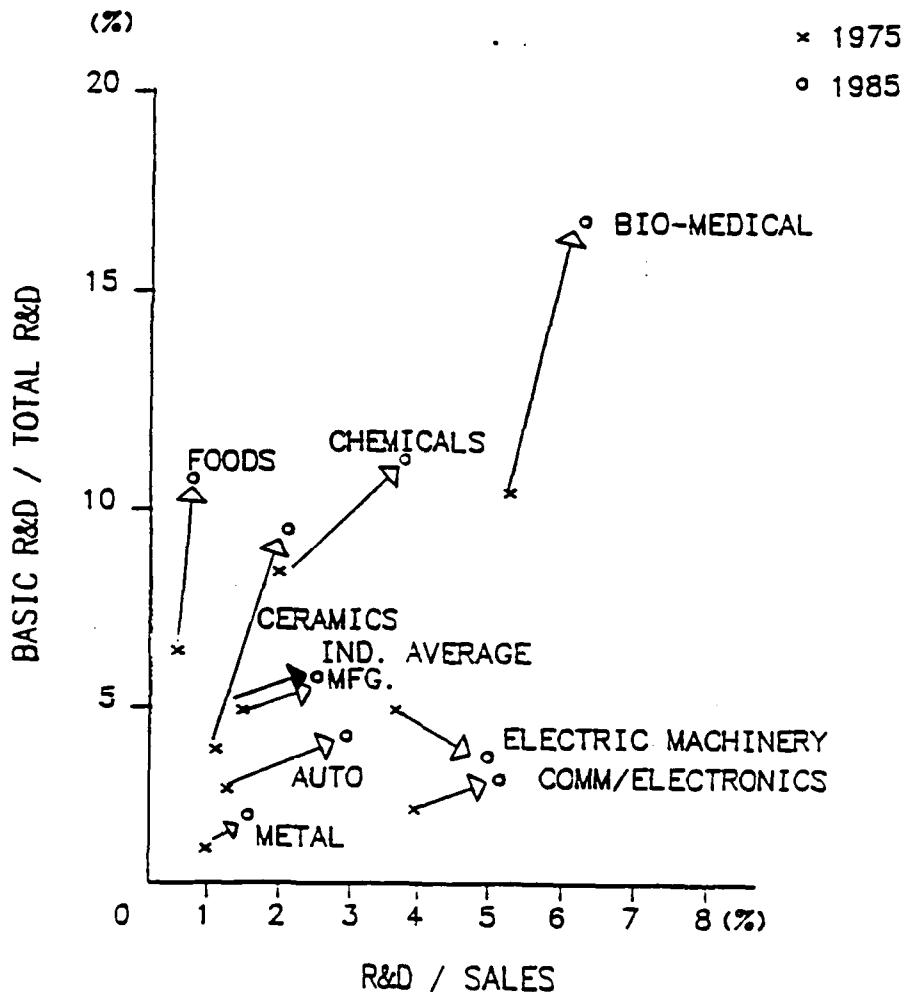
SOURCE: JAPAN STATISTICS BUREAU M.G.T.  
& COORDINATION AGENCY  
PRIME MINISTER'S OFFICE

### ENVIRONMENT -- R&D/SALES BY INDUSTRY

R&D spending as a percentage of sales has grown from an average 1.4% to 2.5% across all industry segments. This chart attempts to show the relationship of basic R&D to total R&D as well as the R&D/sales percentage.

The bio-medical industry is the leader in both the basic research and percentage of sales categories, with communications and electronics second in percentage of sales.

The strong increase in those areas that are still growing in sales shows that they are viewed as emerging and in need of new technologies for continued growth.



SOURCE: JAPAN SCIENCE AND TECHNOLOGY AGENCY

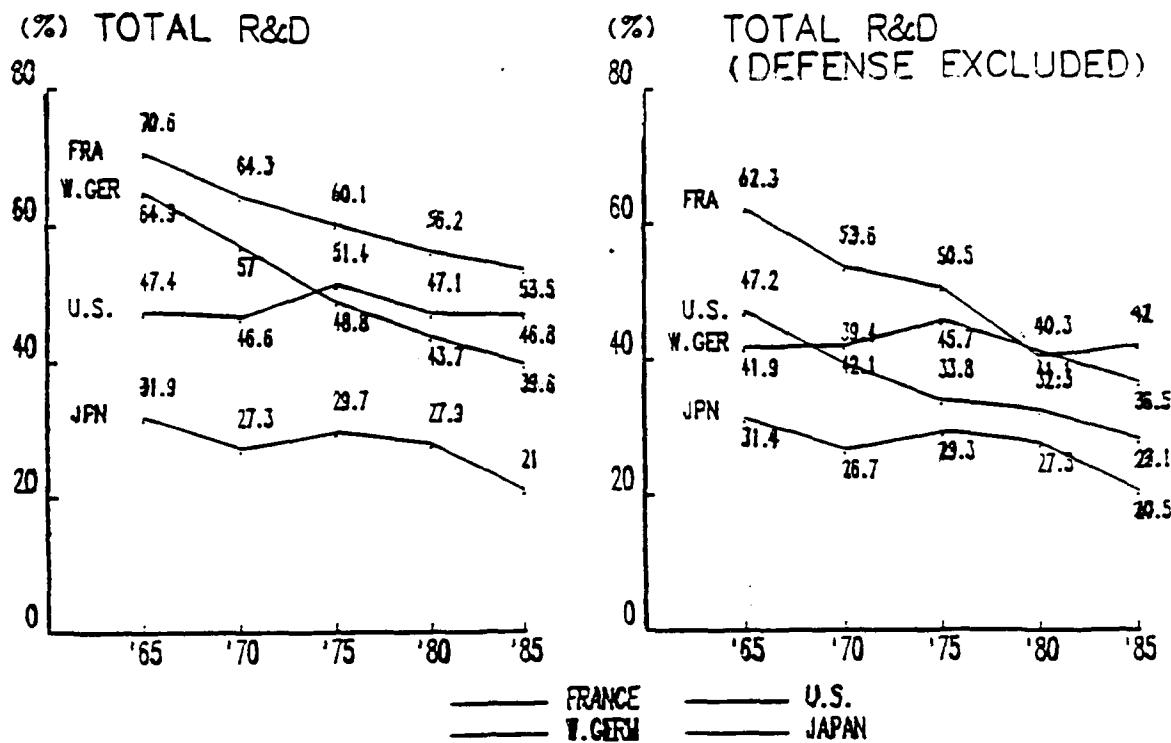
## ENVIRONMENT -- GOVERNMENT-SPONSORED R&D

When viewing government-sponsored R&D expenditures, the trend of a reduced level of government content is clear worldwide. Japan's low government participation is not as pronounced when the defense-oriented projects are removed.

The defense projects are very limited and represent less than 1% of R&D in Japan. This is accentuated by the influence of article 9 of the Japanese constitution which prohibits the development or implementation of offensive military equipment. As reported in the July 4, 1988, issue of TIME magazine, the Japanese Diet last year removed the restriction that defense spending be less than 1% of the GNP. The 1988 budget will be 1.013% of the estimated GNP, so there has not been a major shift in the practical spending limits in Tokyo: Japan now pays 40% of the \$6 billion cost of keeping 60,000 U.S. military personnel in Japan.

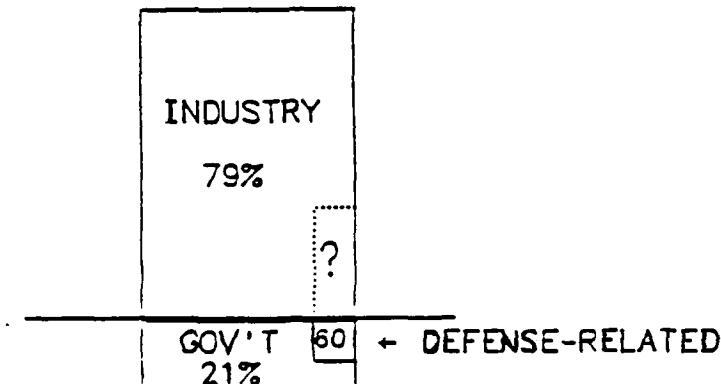
The defense content of the industry-funded R&D is not reported and is very difficult to assess. There is an obvious link between the commercial R&D that enables the development of products that end up in military systems. The July 11 Yomiuri Shimbun reported that, at the June 13-15 Conference on Science and Weaponry in Sweden, it was stated that 65% of the semiconductors used in U.S. weapon systems are supplied by Japan. The theory proposed at this conference sponsored by the International Scientific Policy Council is that there can be significant "spin-in" from industry R&D in addition to the much publicized "spin-off" from government-sponsored projects to commercially viable technologies.

## ENVIRONMENT - GOVERNMENT SPONSORED R&D



### JAPAN R&D

¥8,890B (1985)

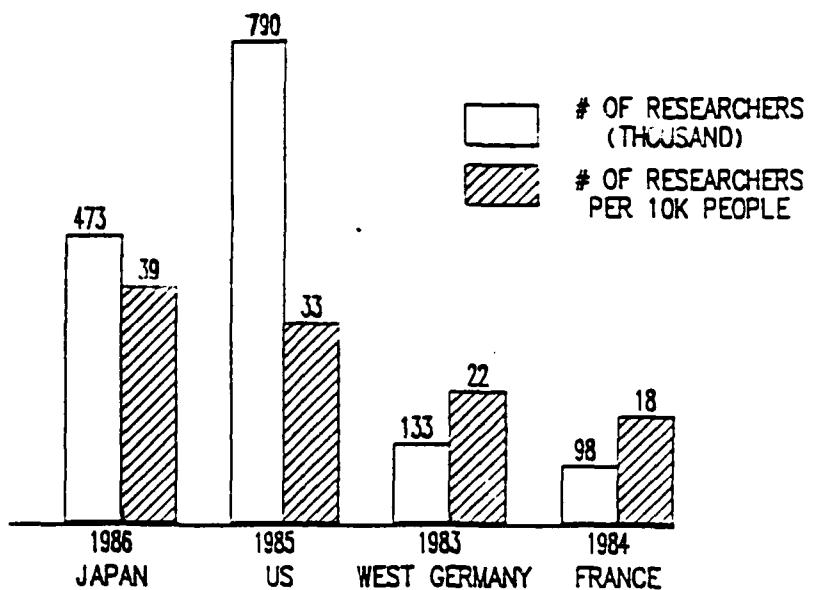


SOURCE : JAPAN SCIENCE AND TECHNOLOGY AGENCY  
SCIENCE & ENGINEERING INDICATORS, 1987  
NATIONAL SCIENCE BOARD

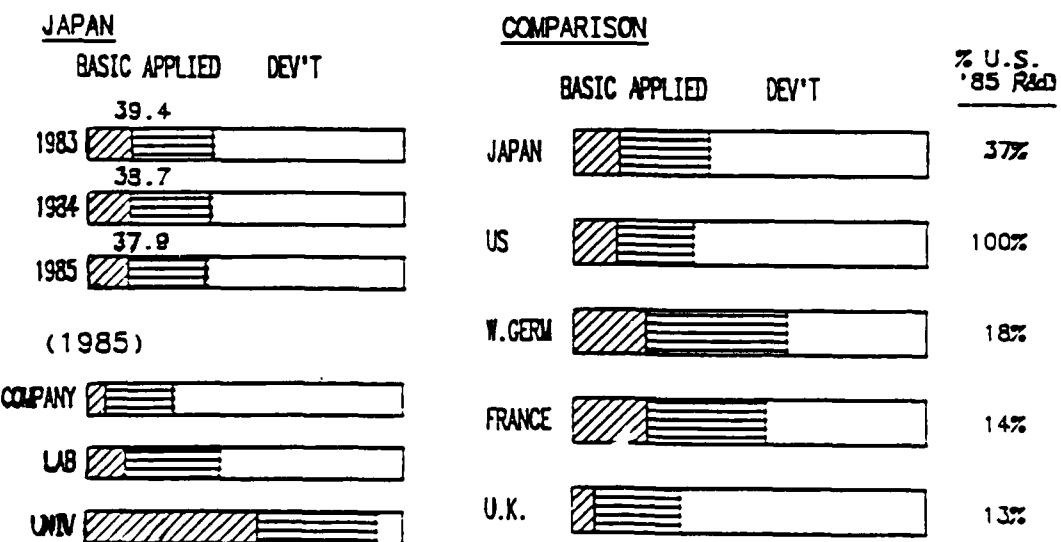
## ENVIRONMENT -- R&D POPULATION/TYPE

Although Japan ranks second behind the U.S. in total number of researchers, it leads the world in number per 10,000 people in the related countries.

When the distribution of R&D funds by type is viewed, it is evident that the amount spent on basic research has not changed over the past 15 years. The portion spent by Japan on applied and basic research is similar to that of the U.S. but is less than that of France and West Germany.



## TYPE OF RESEARCH PERFORMED



## ENVIRONMENT -- NOBEL PRIZE WINNERS

When a review of the Nobel prizes awarded in natural science is conducted, Japan is not in the race with the major developed countries.

In 1985, the Diet established a law, Kiban-ho, to stimulate the funding of basic research in fundamental technologies. It is important to note that the government does not fund these areas directly, but in various cooperative jointly funded projects with industrial partners. Both low interest loans and tax benefits are offered to those companies that participate in the following areas:

- Electronics
- Biotechnology
- Advanced materials
- Communications

Some of the approved projects are:

- Second-generation OEIC
- Synchotron orbital radiation
- Technique for use of optical measuring in communications
- Electronic dictionary for natural language processing

As discussed in the technology section, the above basic research is essential if Japan is to continue to turn the technology crank in the area of semiconductors, communications, and artificial intelligence.

# ENVIRONMENT - NOBEL PRIZE WINNERS

COUNTRY	1901	1946	RECENT 10 YRS
	1945	1987	
U.S.	19	123	34
U.K.	25	38	6
GERMANY	36	18	6
FRANCE	16	7	2
SWEDEN	6	9	4
U.S.S.R.	2	8	1
HOLLAND	8	2	1
SWITZERLAND	4	7	3
AUSTRIA	7	1	-
DENMARK	5	2	1
ITALY	3	4	2
BELGIUM	2	3	-
JAPAN	-	5	2
OTHERS	8	16	2
TOTAL	141	243	64

## JAPAN GOVERNMENT RESPONSE

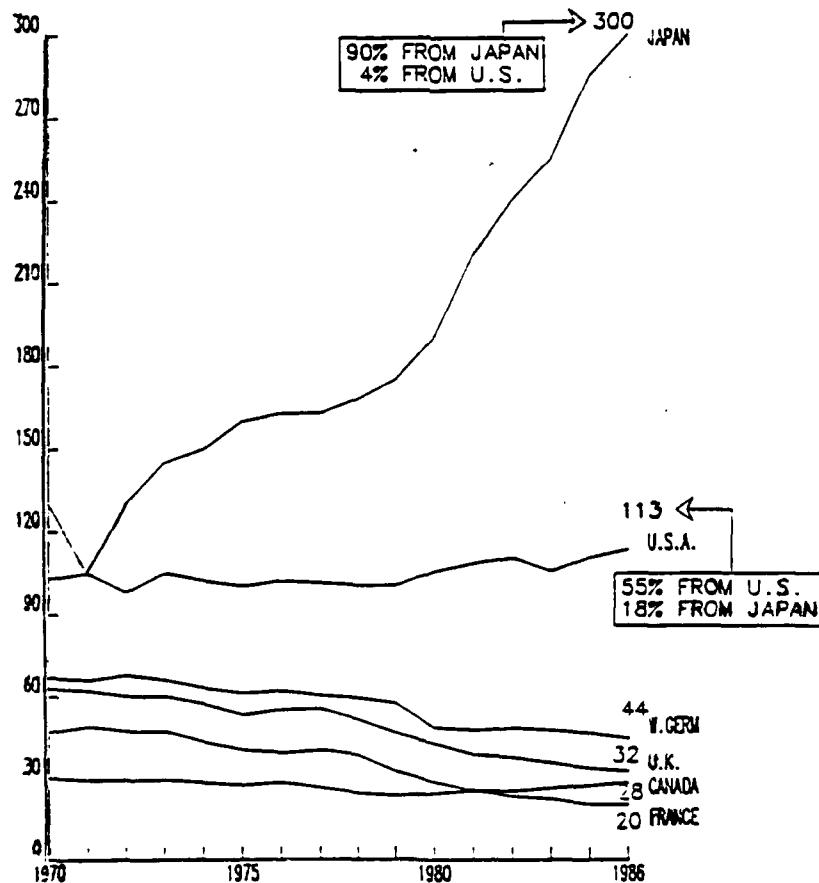
- ESTABLISHED KIBAN-HO - NEW LAW (1985) TO FACILITATE RESEARCH IN FUNDAMENTAL TECHNOLOGIES
- FOCUS AREAS
  - ELECTRONICS
  - BIG-TECHNOLOGY
  - ADVANCED MATERIALS
  - COMMUNICATIONS
- KEY TECHNOLOGY CENTER PROVIDES:
  - SPECIAL TAX TREATMENT
  - FINANCING
- KIBAN-HO R&D PROJECTS
  - 2ND GENERATION OEIC (TOSHIBA, NEC, OKI, SUMITOMO)
  - SYNCHROTRON ORBITAL RADIATION (NEC, FUJITSU, MITSUBISHI, TOSHIBA)

SOURCE: NOBEL PRIZE FOUNDATION  
 JAPAN SCIENCE AND TECHNOLOGY AGENCY  
 MITI 2000 VISION REPORT

## ENVIRONMENT -- WORLDWIDE PATENTS

Measuring the output of R&D is difficult, but if patent applications are a measure of development and applied research activities, the Japanese clearly lead the world. When a listing of patent applications is assembled, the number of applications in Japan totals over 300,000 and is growing at a rate comparable to the increase in R&D spending.

The other significant item is the high rate of applications in Japan primarily submitted by companies and individuals from within Japan. When the much lower content (55%) of the U.S. patent applications by U.S. researchers is taken into consideration, the Japanese produce more than three times as many domestic patent applications and nearly six times the number per researcher.

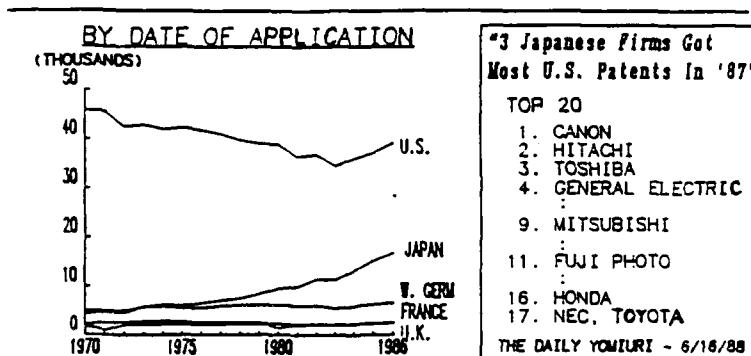


## ENVIRONMENT -- U.S. PATENTS

When the number of patents awarded is analyzed in addition to the rate and number of applications, the Japanese participation is also pronounced. Of the 71,000 patents awarded in the U.S. in 1986, the Japanese had 16,000 and the U.S. 39,000.

The Daily Yomiuri newspaper published that in 1987 the top three companies receiving patents were Japanese, as were eight of the top 18.

The trend in awards is more impressive when the percentage of patents in key technology areas is compared to a decade ago. In most areas, percentage gains were made at the expense of both the U.S. and others with the exception of the key telecommunications area. It is also important to note that the total number of patents awarded has actually dropped from 72,000 in 1975 to 70,880 in 1986. Thus, in these key technology areas, the U.S. patents have actually decreased since 1975.



### U.S. PATENTS GRANTED BY TECHNOLOGY (SHARE)

		U.S.	OTHER	JAPAN
TELECOMM.	'75	66	20	14
	'86	52	22	25
LASER	'75	63	23	14
	'86	50	14	35
SEMI-CONDUCTORS	'75	68	19	13
	'86	57	14	29
COMPUTER	'75	77	18	5
	'86	69	11	20
TOTAL	'75	63	26	9
	'86	54	21	19

SOURCE: U.S. DEPARTMENT OF COMMERCE,  
PATENT AND TRADE MARK OFFICE

## ROLE OF GOVERNMENT -- THREE STAGES OF GROWTH

The government and MITI have played a key role in the formation and development of the computer and telecommunications industries in Japan. The three stages defined here are an attempt to segment the development activities so that the actions taken by government can be better understood.

The Law on Extraordinary Measures for the Promotion of the Electronic Industry (Denshinho) was enacted in 1957. It gave MITI the power to:

- 1) Outline programs on R&D planning
- 2) Provide financial assistance to manufacturers
- 3) Formulate plans to realign the industry.

Under this law the Electronics Industry Council was formed and the major manufacturers subsequently formed the Japan Electronic Industry Development (JEIDA) in 1958 for the promotion of their industry, which was perceived to be far behind that of the U.S.

In September of 1963, the Japanese government decided that preferential treatment should be given for the use of Japanese products in government. MITI also sent a letter to the business sector asking for them to also "buy Japanese." The stated reason was to save foreign exchange reserves. The policy lasted until 1972 for all but computer products. There was no official lifting of the restriction on computers, but the government did approve the purchase of a U.S.-made computer in 1977.

The law on Extraordinary Measures for the Promotion of the Scientific Electronic and Machinery Industries (Kidenho) was in place from 1971 through 1977. Specific product groups were identified for "Enhancement Programs." They were:

- 1) Digital computers
- 2) Integrated circuits
- 3) Magnetic disk equipment
- 4) Facsimile devices
- 5) High purity silicon

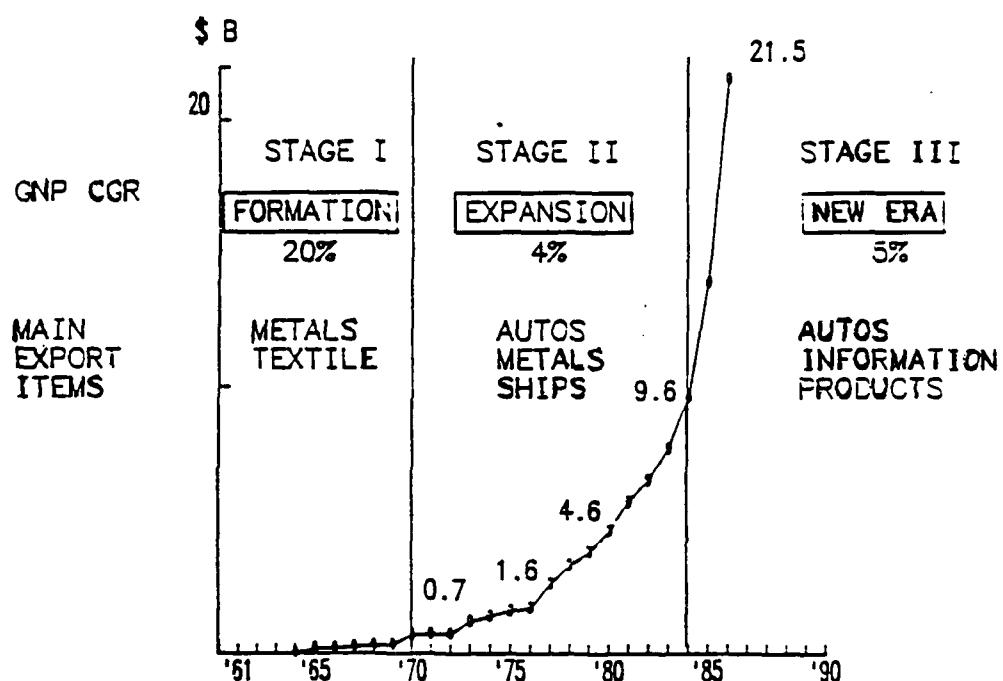
The law authorized the government to obtain or support funds for these selected enhancement programs and empowered MITI to direct the manufacturers to engage in concerted activities pertinent to:

- o Industrial standards
- o Technology enhancements
- o Limitation of product types
- o Procurement of raw materials and components
- o Use of production facilities

In 1978, the Kidenho was modified and replaced by Kijoho, which added the software industry to the list of industries covered. They did, however, exclude the firms that produced software for specific sectors. This encouraged the build-up of the software houses in Japan and focused them on custom application development. Kijoho expired in June of 1985 and has not been replaced.

## ROLE OF GOVERNMENT - THREE STAGES OF GROWTH

### 3 JCMs EDP REVENUE TREND



	1970	1984	1986
EXCHANGE RATE (YEN/\$)	360	243	173
% TO US GNP PER CAPITA	34%	65%	94%
EXPORT % TO GNP	5%	14%	12%
TRADE BALANCE	\$4B	\$44B	\$93B
OVERSEAS INVESTMENT	\$1B	\$10B	\$22B

SOURCE: JAPAN STATISTICS BUREAU, OECD

## ROLE OF GOVERNMENT -- RISK SHARING

Opto-electronic research was needed to accelerate the development of technologies for the communications industry. The following graph shows the relationship of the industrial participants and the joint research laboratory. The lab is a quasi-governmental institution that was jointly funded and staffed by the government and the corporate partners.

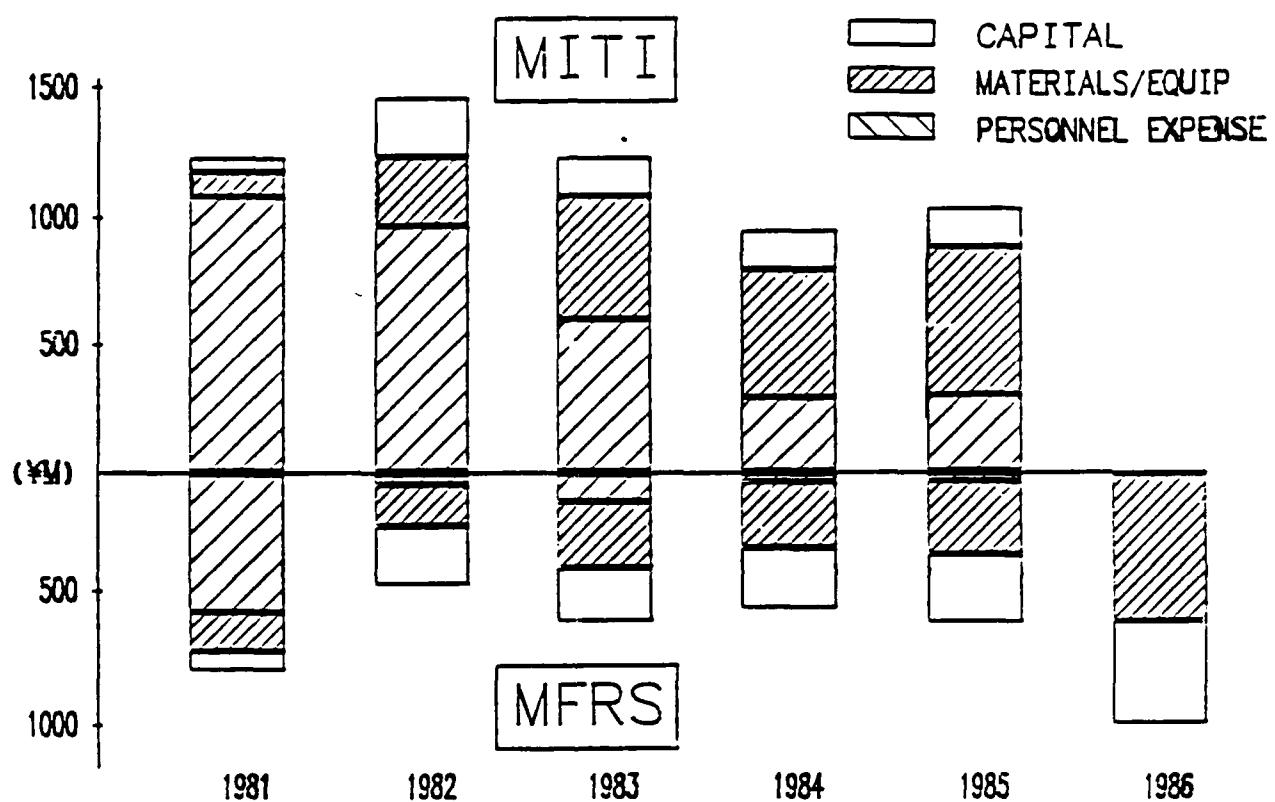
The graph shows the shift in funding and staffing requirements as the project progresses. The project is typical in that the initial stages are more exploratory and require more staffing and expense funding than capital and materials. As the project continues, the government staff involvement decreases and the capital and material costs escalate as the concepts are exercised via testing and experimentation of many prototypes.

The objective of such joint projects is to find and eliminate the "dead ends" in an attempt to accelerate the identification of viable development options. At the end of the joint project the testing results and prototype concepts are published and distributed to the partners and, in some cases, made available to all manufacturers interested in continuing the development. The independent companies then have the option to continue the development in a competitive manner with the rest of the industry. Although the joint projects do accelerate the research output, they do not eliminate the competition between vendors once the technology has been proven viable.

The government staff members are shifted to other projects as they are no longer needed in their current project. This gives the government employees the chance to participate in a number of key research efforts and to work in partnership with commercial researchers.

## ROLE OF GOVERNMENT - RISK SHARING

(E.G. OPTO-ELECTRONICS JOINT RESEARCH LAB.)



- OBJECTIVE : 1 GB/SEC OPTO-ELEC. IC
- BUDGET : MITI = \$40M/ MFRS = \$20M (© YEN 150)
- APPROX. 50 ENGINEERS AND 10 ADMINISTRATION
- 6 JCMs, MATSUSHITA, SUMITOMO, UNIVERSITIES, ETC.

SOURCE : Optronics, Vol. 62, 1987

### ROLE OF GOVERNMENT -- STAGE III

As the export boom began to hit on all cylinders in the early 1980s, it became obvious to the key leaders in Japan that the trade imbalance was causing friction with Japan's partners and allies. Prime Minister Nakasone commissioned the Economic Structure Team, led by the former head of the Bank of Japan, Maekawa, to recommend actions to alleviate the trade imbalance. This blue-ribbon committee, consisting of 17 leaders from industry, government, and academia was asked to develop a long-term direction for Japan that would allow them to become a less threatening trading partner with the West without slowing the growth of the economy and the increasing standard of living.

On April 7, 1986, the team submitted its report to the Prime Minister's office (Sorifu) with the recommendation that significant changes in the domestic economy were necessary to relieve trade tension and to support the needed increase in imports from the West, particularly the U.S. The following month at the Economic Summit held in Tokyo, Nakasone announced his guidelines for the promotion of economic structural change in Japan. He also announced the formation of a small high level committee, which he headed, to promote the need for change and to spread the word that the government of Japan was intent on addressing the issue. This was the beginning of a well organized media and political campaign designed to gain a consensus among the people, Diet members, and industry.

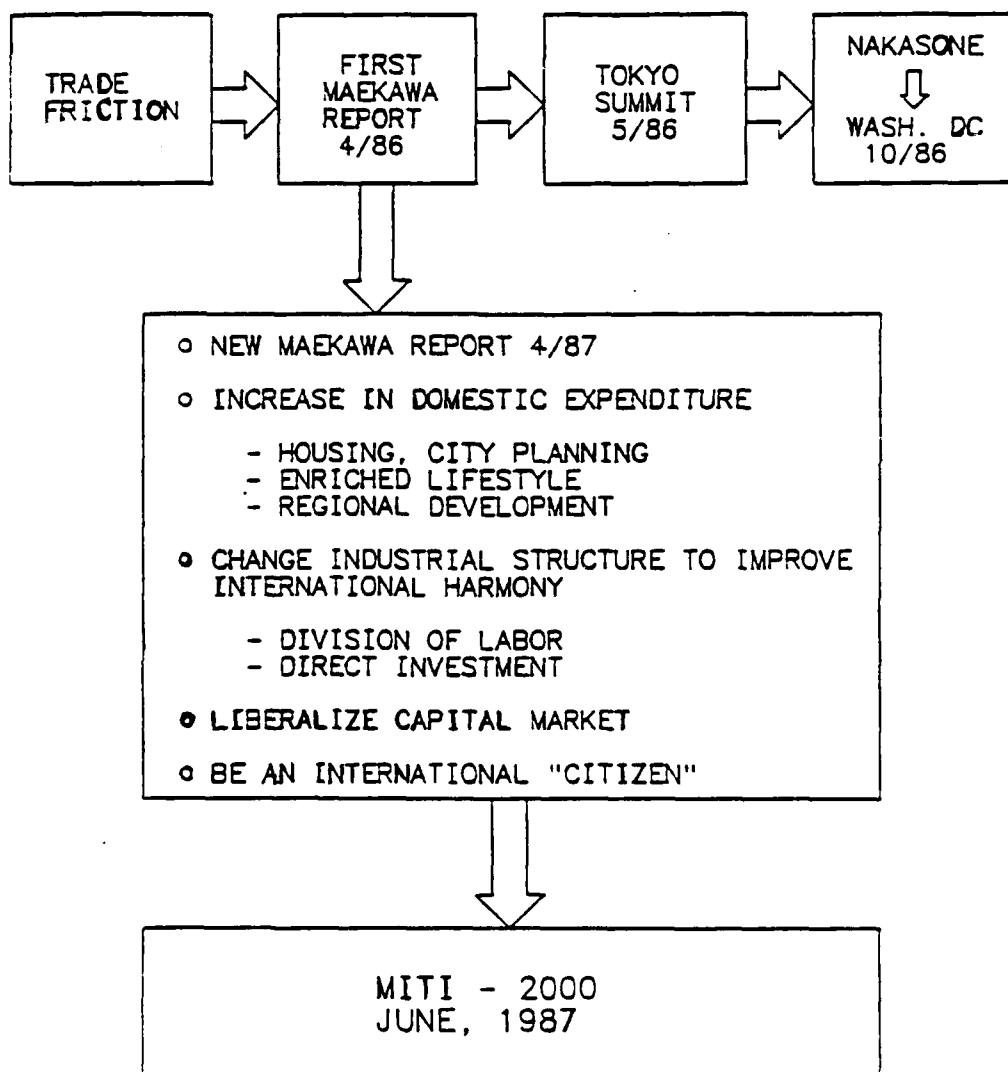
On the basis of positive response from his constituents and the U.S. government, Nakasone asked the Maekawa team to develop more specific action plans for the short term and to integrate more detailed studies from MITI. The April 1987 Maekawa Report II was now more specific in the call for increased government and industry spending to stimulate the domestic economy with the emphasis on housing, city planning, and improving the quality of life for the workers in Japan. It was also recommended that regional development be emphasized to off-load the Tokyo, Osaka areas and to create working environments that did not require the long commutes and high cost of living that existed in the major metropolitan areas.

Although the financial markets had begun to open, with the first foreign members having recently been given seats on the Tokyo Stock Exchange, there was a call for an increased opening of Japan's capital market and for the Bank of Japan to accept a stronger international responsibility. The fast drop of the U.S. dollar in 1986 clearly demonstrated the need for government intervention in the volatile international money markets that now operated 24 hours a day.

Another key element of the new-style Maekawa report was the call for Japanese companies to "internationalize" and begin moving more of their operations and manufacturing off-shore. This has been executed well, with the largest shift being into Asia as the Japanese companies build their relationships with Asian governments through their subsidiaries and through participation in joint projects to build up the support infrastructure of the Asian countries.

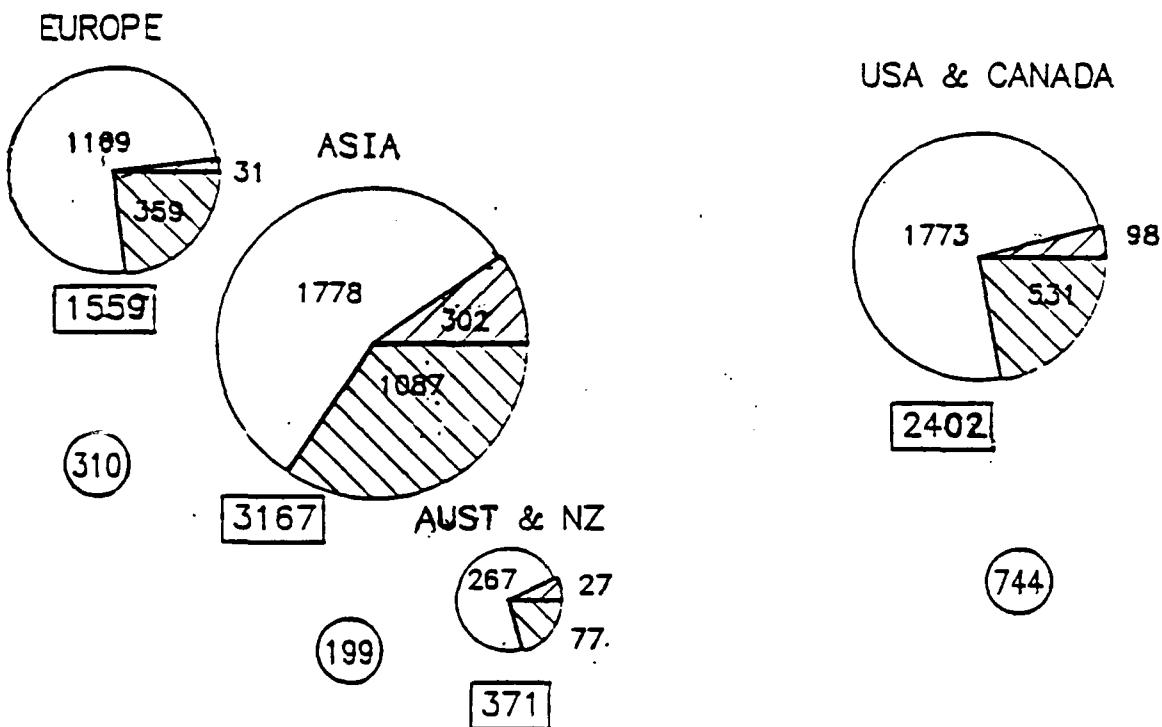
## **ROLE OF GOVERNMENT - STAGE III**

## "JAPAN AT A CRITICAL TURNING POINT"

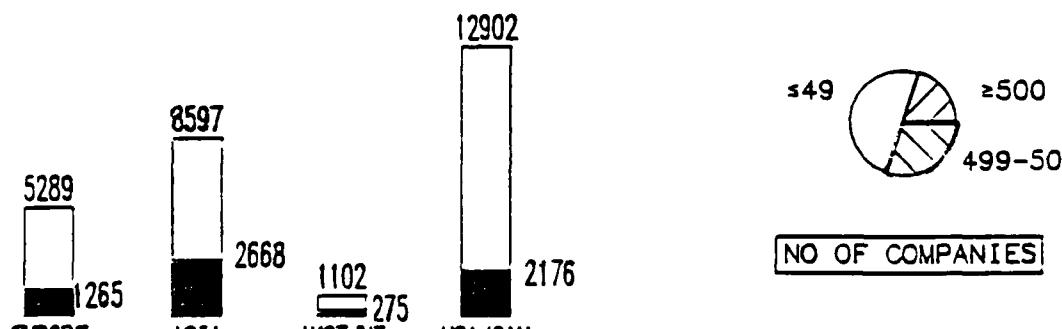


## ROLE OF GOVERNMENT - JAPAN BASED COMPANY DEMOGRAPHICS

### NUMBER OF JAPAN BASED COMPANIES



### NUMBER OF ASSIGNEES



JAPANESE ASSIGNEES  
JAPANESE EXECUTIVE

SOURCE : TOYO KEIZAI AS OF JULY, 1987

## ROLE OF GOVERNMENT -- MITI 2000 VISION

Coincident with the development of the Maekawa Report, MITI had been developing a long-term view of selected key industries and the role they would play in the domestic economy by the year 2000. The objective was to quantify the relative participation of the industry sub-segments and to determine what dependencies existed in order to support the growth and development as forecast in the report.

Although visions of the 21st century were completed for energy, space, biomedical, industry and advanced materials, we will focus on the information industry vision since it is the most recent and is considered the bedrock for the needed shift to high technology as described by the Maekawa reports.

## ROLE OF GOVERNMENT - MITI-2000 VISION

		1984	1985	1986	1987	1988	→ 21 CENTURY
INDUSTRY STRUCTURE	MAEKAWA REPORT	(REPORT ON DIRECTION ACTION PLAN REPORT)	LAW PLAN BY INDUSTRY				- ASSIST ADAPTATION - FINANCE SCRAP - LOAN - TAX, DEPREC. - PREVENT HOLLOWING FROM SUNSET - SHIP B. STEEL, TEXTILE TO SUNRISE - HIGH TECH, SOFT, SVC
ADVANCED MATERIALS	L-TERM VISION REPORT	• LAW (KIBAN-HO) • CENTER (KIBAN-CENTER)					- E/P (MAX 70%) TO JV - PROMOTE BASIC/APPLIED R&D - LOAN, TAX - GOV'T WINDOW/SUPERVISING - 2000 MARKET SIZE = Y5.4T
ENERGY	21C VISION REPORT						- THROUGH 2030 - MULTIPLE SOURCE OF SUPPLY OIL 50% + 30%
INFOR-MATION		21C VISION REPORT					
BIO-INDUSTRY	VISION REPORT (TECHNICAL ASPECT)			L-TERM VISION REPORT (INDUSTRY ASPECT)			- PARTICIPATION BY STEEL, PLANT, ELECTRIC - BEHIND US - BIO TECH CENTER FOR JOINT R&D - INFO NETWORK - SECURITY
SPACE		SPACE DEV'T COMMITTEE L-TERM PANEL REPORT					- ¥600B REQUIRED BY 2000 - ¥4T MARKET AT 2000

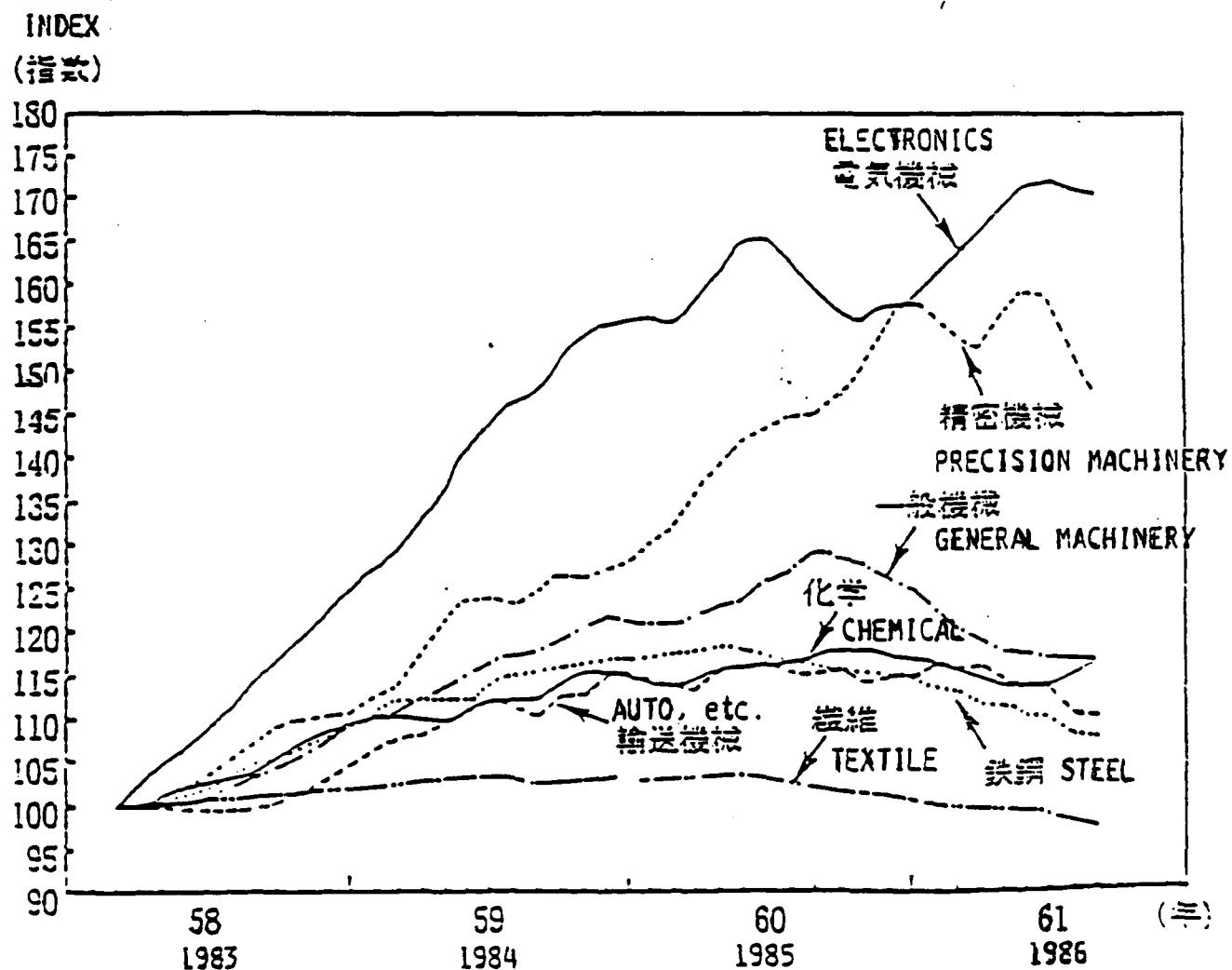
## (参考資料8) 産業構造の変化と情報化

### CHANGE OF INDUSTRY STRUCTURE

#### 1. 産業構造の変化

##### PRODUCTION TREND BY FIELDS

###### 1-(1) 業種別生産の推移



(出典) 経済企画庁「日本経済の現況」(62年版)

SOURCE: AGENCY OF ECONOMIC PLANNING  
"CURRENT STATUS OF JAPAN ECONOMY - 1987"

(ポイント)

1. 電気機械・精密機械の生産量の伸びは、他業種に比べ非常に高い。
2. 製造業における産業構造の激しい変化がうかがわれる。

## INFORMATION INDUSTRY -- MITI 2000

The MITI 2000 Report was a follow-on to a similar report, prepared in 1976, that projected the growth and change in the industry by the year 1985. History proved that the original projections were extremely accurate. Even if it did not exactly predict the role that personal computers would play by 1985, the report did accurately predict the user and marketplace demand and the types of applications that would drive that demand.

An interim report was published in 1981 that did not update the quantified forecast but did point out the change in the industry that would increase the role of telecommunications and information services by the 1990s. These were forecast to be the high growth and high margin parts of the industry and the key to geographically distributing the workload and work force. The role of computers in the home was amplified on the basis of the forecast view of large value-added networks based on all-digital fiber-optic communication systems that were planned for the major metropolitan areas.

The MITI 2000 Report was to focus on the impact of internationalization, end user system requirements, and the expanded role of telecommunications in Japan and internationally.

Since this work was done as part of MITI's Industry Structure Council, the data used and the input/output models have been agreed to by all industry sections in MITI and did not represent just one group's view of their particular industry in the future without regard for the other industry growth rates and resultant industry structure.

# INFORMATION INDUSTRY - MITI 2000

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A VISION OF THE INFORMATION INDUSTRY  
IN THE YEAR 2000  
JUNE 1987

## PURPOSE

- PRIVATE SECTOR CONSENSUS
- INDUSTRIAL POLICY BASIS

## PRIOR VISIONS

	<u>1974 ACTUAL</u>	<u>1985 PROJECTION</u>	
1976 PROJECTION	1,946T¥	7,467T ¥	(7,636T¥)
13% CGR - DP HARDWARE			
1981 SCENARIO			

- INCLUDED TELECOMMUNICATIONS & INFORMATION SERVICES
- BUSINESS & HOME

## CURRENT OBJECTIVES

- QUANTIFICATION
- NEW TRENDS
  - INTERNATIONALIZATION OF JAPANESE BUSINESS
  - TELECOMMUNICATIONS LIBERALIZATION
  - END USER SYSTEMS

## INFORMATION INDUSTRY -- GROWTH

The most significant projection that came from the Vision 2000 report was the dramatic increase in the percentage of GNP that the information industry would experience by the year 2000. The share of GNP was projected to rise from 6.4% today to 20.6%, while the overall GNP growth would be 5% annually. Although the electronic and data processing equipment sector would still make up nearly 75% of information industry, they would be driven and enabled by the rapid expansion of the communications and services businesses.

The expanding industry would create a projected 2.5 million new jobs, which represented 44% of all new jobs created during the period between 1987 and 2000. In addition, 2,000 new companies would be formed to capitalize on the new industry and they would account for 26% of the industry revenue. Many of these new ventures would be spin-offs of established companies that may not experience the same rates of growth as the computer industry. We see examples today of major companies in the so-called "sunset" industries expanding into information services. Nippon Steel and Sumitomo Heavy Industries are two such examples. A chart of the Nippon Steel restructuring is included to better explain this shift in mission that is already happening in Japan.

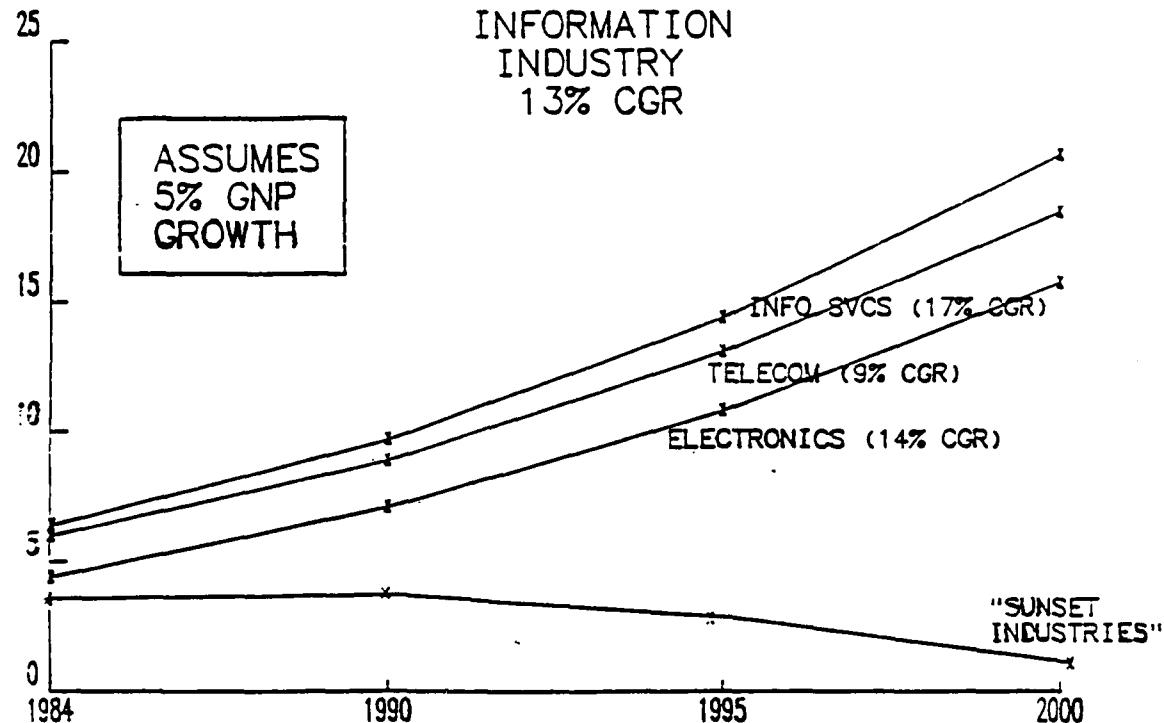
	1984	1985	1986	1987	1988	→ 21 CENTURY
INDUSTRY STRUCTURE	MAEKAWA REPORT	REPORT ON DIRECTION ACTION PLAN REPORT	LAW PLAN BY INDUSTRY			- ASSIST ADAPTATION - FINANCE SCRAP - LOAN - TAX, DEPREC. - PREVENT HOLLOWING FROM SUNSET - SHIP B. STEEL, TEXTILE TO SUNRISE - HIGH TECH. SOFT. SVC
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SPACE		SPACE DEV'T COMMITTEE L-TERM PLAN REPORT				- ¥600B REQUIRED BY 2000 - ¥4T MARKET AT 2000

SOURCE: MITI 2000 VISION REPORT

## INFORMATION INDUSTRY - GROWTH

### MITI 2000 : INDUSTRIAL STRUCTURE CHANGES

% OF GNP

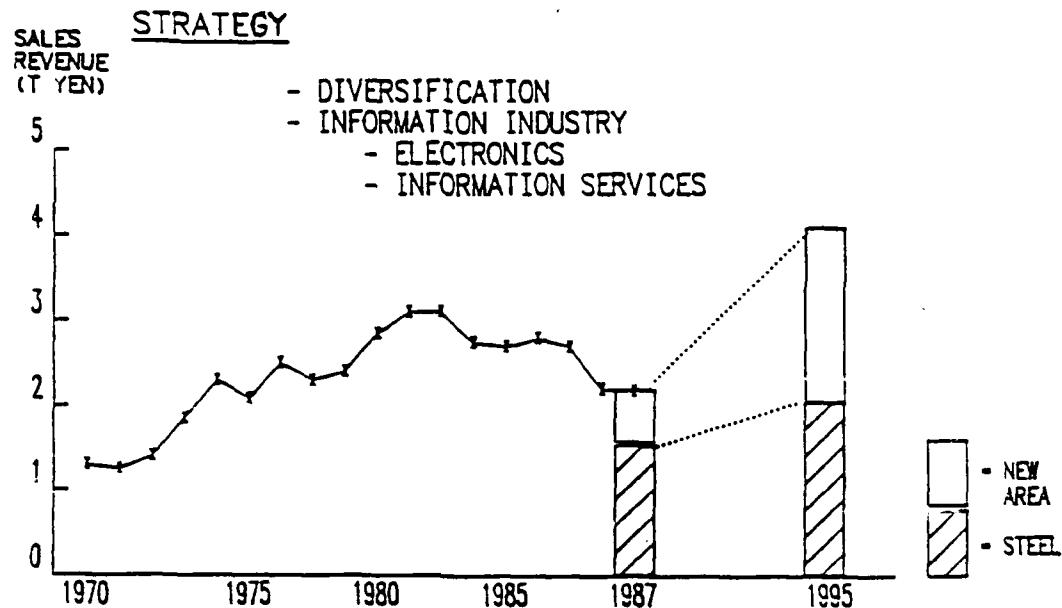


11.1 %	16.6 %	24.3 %	33.1 %
INVESTMENT IN INFORMATION AS % OF CAPITAL SPENDING			

- CONSUMER DEMAND 8% → 29%
- POLICY INITIATIVES REQUIRED
- INFORMATION INVESTMENT INCENTIVES
- 2.5 MILLION NEW JOBS 44% OF TOTAL
- 2000 NEW COMPANIES 26% OF INDUSTRY SALES

SOURCE: MITI 2000 VISION REPORT

## INFORMATION INDUSTRY - NIPPON STEEL RESTRUCTURE



KIBANHO: THE ACT FOR SMOOTH CHANGE OF INDUSTRY STRUCTURE (APR. 1987)

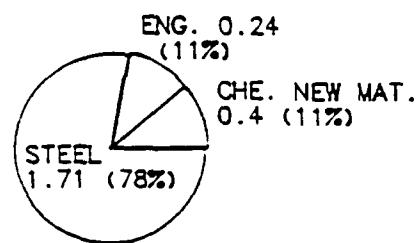
TAX: OLD FACILITY DISPOSITION SCRAPPING  
 NEW FACILITY ACQUISITION  
 PLANT AND LAND FOR NEW BUSINESS

JAPAN DEV'T LOAN: LOAN FOR NEW FACILITIES

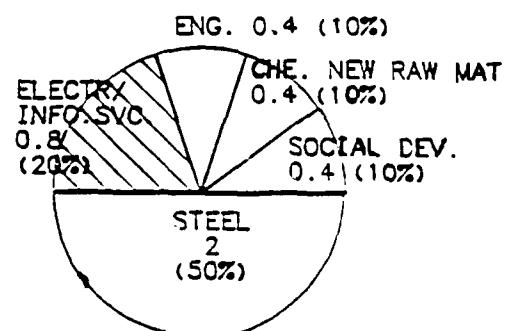
JAPAN KEY TECHNOLOGY CENTER

### REVENUE GOAL (1995)

(TRILLION YEN)



1987 - ¥2.18



1995 - ¥4

SOURCE: NIPPON STEEL CORP. PRESS RELEASE

## INFORMATION INDUSTRY -- REQUIREMENTS

This chart is a brief summary of the findings and recommendations of the Vision 2000 report. There was a clear call for a focus on the shortage of programmers and service organizations along with the needed key technologies as dependencies that could limit the growth and development of the industry.

A recurring theme of the report is the concept that the information industry and the services it performs are a public asset but that the responsibility for implementation lies with private corporations and individuals.

### MITI 2000 : NEEDS

#### EXISTING NEEDS

IMPROVED COST PERFORMANCE

ENRICHED SOFTWARE POOL

EFFICIENT SOFTWARE DEVELOPMENT

SOPHISTICATION & DIVERSIFICATION

#### EMERGING NEEDS

FREE INTERCONNECTION

INTEROPERABILITY

INTEGRATED SYSTEMS

SOFTWARE TO COPE WITH  
COMPLEXITY  
EXPANDED INFORMATION  
ASSETS

SECURITY & PRIVACY

MULTI MEDIA DATA BASES

#### POLICY INITIATIVE

VLSI PACKAGING  
TECHNICAL DEVELOPMENT  
ISDN - TARIFF

TRAINING  
INVESTMENT IN ASIAN NICS  
PACKAGED SOFTWARE  
SIGMA PROJECT

HIGH VALUE ADDED  
INFORMATION SERVICES  
INDUSTRY

OSI  
SYSTEMS INTEGRATION  
SERVICES  
DISTRIBUTION TO  
END USERS  
INFORMATION LITERACY  
"FRIEND 21"

INTERFACES  
BETWEEN APPLICATION  
SW & BASIC SYSTEM (SAA)

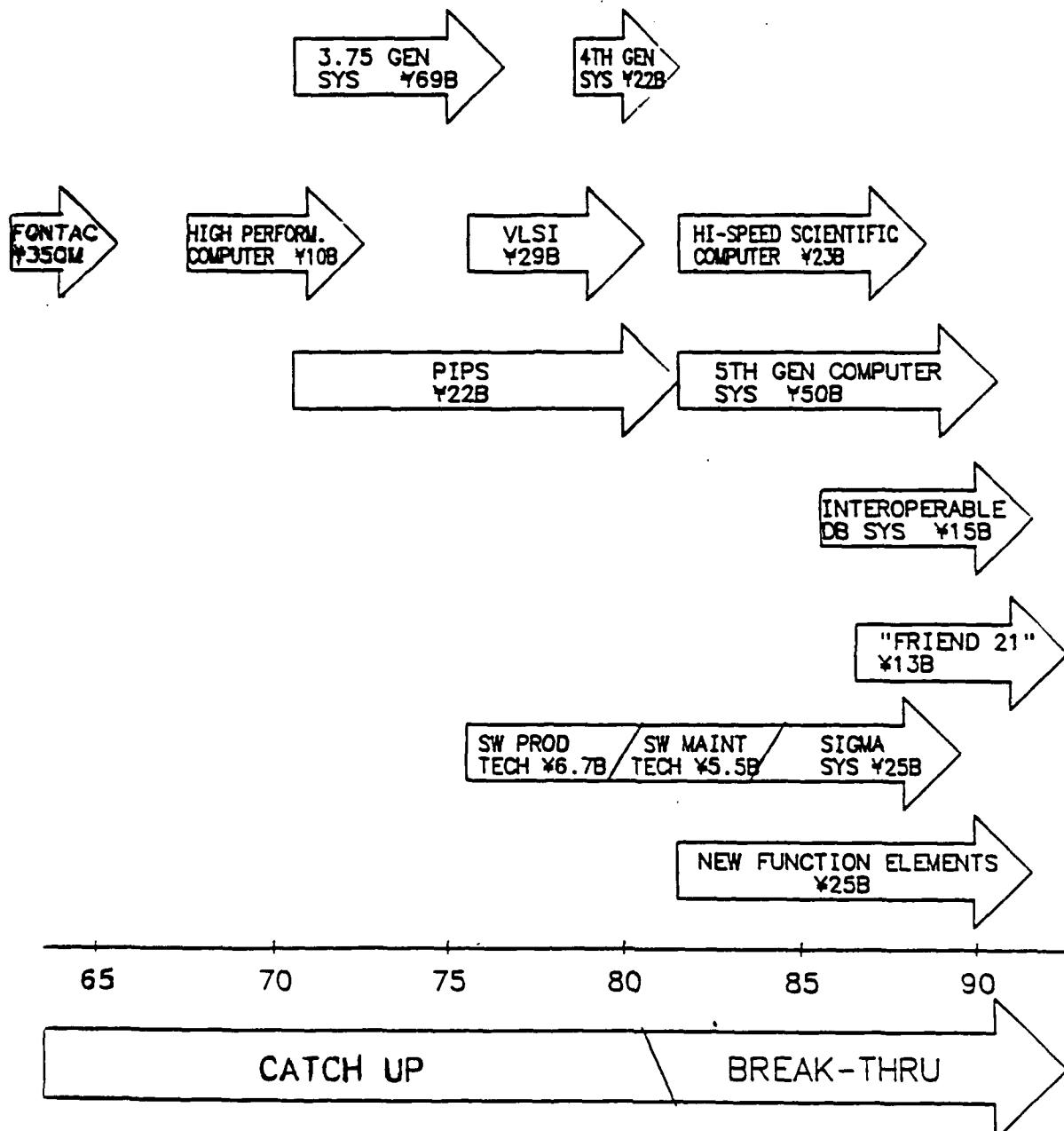
GOVERNMENT SUBSIDY

INFORMATION PROVIDING  
INDUSTRY

**PUBLIC ASSET - PRIVATE RESPONSIBILITY**

# INFORMATION INDUSTRY - MITI PROJECTS

## GOVERNMENT SPONSORED COMPUTER R&D PROGRAM



## MAJOR NATIONAL PROJECTS

'79 '80 '81 '82 '83 '84 '85 '86 '87 '88 '89 '90

### SEMICON./ELECTRONICS/COMPUTER

- SUPERCOMPUTER DEV.
- OPT. APPLY MEASURE./CTL
- SUPER LATTICE
- 3D DEVICE
- 5th GEN. COMPUTER
- APPL. OF SEMICON. LATTICE DISLOCATION
- COMPLETE CRYSTALLIZATION PROJ.
- AUTO. TRANSLATION PROJ.
- 2nd GEN OEIC DEV.
- X-RAY LITHO. (SOR)
- FUZZY COMPUTER
- NEURAL COMPUTER

### MATERIALS

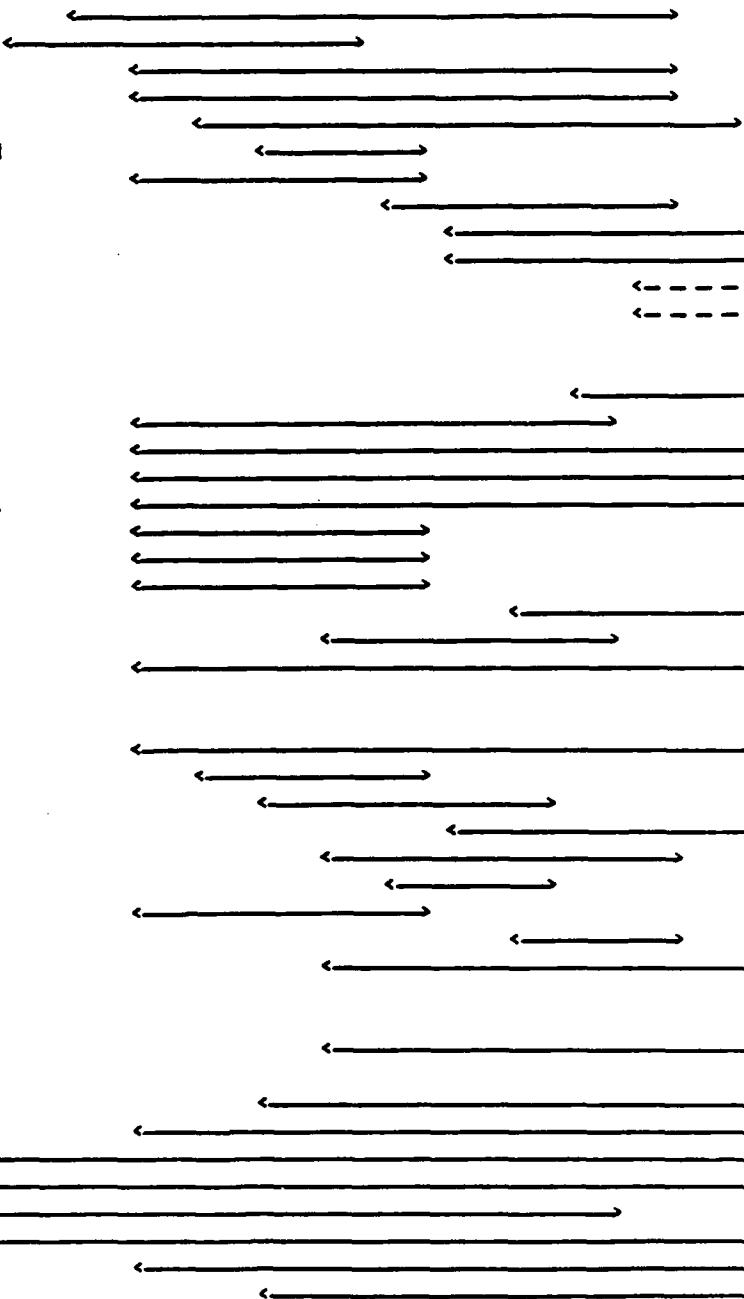
- SUPERCONDUCTIVITY
- HI-PERF. CRYSTAL CTL ALLOY PROJ.
- FINE CERAMICS PROJ.
- CONDUCTIVE POLYMER PROJ.
- HI-EFFICIENCY MICROMOLECULE FILM PROJ.
- ULTRA PARTICULATES PROJ.
- SPECIAL STRUCTURAL MATERIAL PROJ.
- FINE POLYMER PROJ.
- RARE METAL NEW FUNC. PROJ.
- HYBRID MATERIAL
- SUPERCONDUCTING CRYOGENIC PROJ.

### BIO-TECHNOLOGY

- RECOMBINANT DNA
- BIO-POLONICS PROJ.
- BIOLOGY COMM. INTERCHANGE PROJ.
- BIOLOGY PHOTON PROJ.
- BASIC TECH FOR CANCER STUDY
- BASIC TECH FOR BRAIN'S FUNC. STUDY
- STRUCTURAL ANAL. OF DNA BASE SEQ.
- RESPONS. MECHANISM OF IMMUNITY STUDY
- ANTI-CANCER 10 YEARS PROJ.

### OTHERS

- OBSERV. SYS. FOR NATURAL RESOURCE EXPLORATION
- ULTIMATE WORKING ROBOT
- MANGANESE MODULE MINING SYS.
- SATELLITE, H-I, H-II PROJ.
- NUCLEAR FUSION PROJ. T-60
- STOL PROJ.
- DEEP WATER SUBMARINE RES. SHIP
- TORISTAN PLAN
- LASER NUCLEAR FUSION PROJ.



## TECHNOLOGY TRENDS – ADDITIONAL PROJECTS

# AGENCY OF INDUSTRY SCIENCE & TECHNOLOGY

- | NEW FUNCTIONAL ELEMENT DEVICES                    |      |      |         |
|---|------|------|---------|
| - SUPER LATTICE                                   | 1981 | - 90 | 9B YEN  |
| - 3D CIRCUIT ELEMENTS                             | 1981 | - 90 | 8B YEN  |
| - BIO-CHIPS                                       | 1987 | - 96 | 8B YEN  |
| <br>  |      |      |         |
| BIO-TECHNOLOGY                                    | 1981 | - 90 | 26B YEN |
| NEW MATERIALS                                     | 1981 | - 90 | 53B YEN |
| ADVANCED PROCESS SYSTEM                           | 1986 | - 93 | 15B YEN |
| <br>  |      |      |         |
| ○ NEW MANGANESE MINING SYSTEM                     | 1981 | - 89 | 20B YEN |
| ○ AUTO SAWING SYSTEM                              | 1982 | - 90 | 10B YEN |
| ○ ULTIMATE WORKING ROBOT                          | 1983 | - 90 | 20B YEN |
| ○ WATER REUTILIZATION SYSTEM                      | 1985 | - 90 | 12B YEN |
| ○ OBSERVATION SYSTEM FOR<br>RESOURCES EXPLORATION | 1984 | - 90 | 23B YEN |

## JAPAN'S INFLUENCE IN ASIA

The need for internationalization has accelerated the well established move by the major Japanese companies into the other Asian nations. This chart points out that the Japanese government is enhancing that move by expanding its foreign aid program of Overseas Development Aid (ODA). Prime Minister Takeshita announced at the Toronto Financial Summit in June that Japan has established a \$50 billion program for ODA which makes it the largest foreign aid package in the world. Japan's ODA funding has grown from approximately \$1.1 billion in 1976 to an estimated \$9 billion to \$10 billion in FY 1988.

With an emphasis on projects that help develop the communications, transportation, and educational infrastructure of the Asian countries, 65% of the ODA funds go to Japan's Asian neighbors. If capital equipment is needed for the project, one of the conditions of ODA funding is that it be machinery that was built in Japan.

- 65% of ODA Funds to Asia
  - Japan now largest source of foreign aid
  - Capital equipment must be made in Japan
- Corporate Expansion into Asia
  - Manufacturing and distribution facilities
    - \* Manufacturing expertise
    - \* Technology transfer and control
    - \* Strong management guidance
  - Joint participation with local government
  - Build-up of infrastructure and marketplace
  - Largest customers for IC's
  - Continued expansion into low-cost areas
    - \* NICS (Korea, Taiwan, Singapore, Hong Kong)
    - \* Thailand, Malaysia, Indonesia
- MITI Goal - Japan to move from "Manufacturer for the World to "Laboratory for the World"
  - Control manufacturing facilities
  - Stay one technological step ahead
- Balance of trade with the United States

NICS = Japan  
\$50 billion

In addition to ODA, Japanese corporations are aggressively expanding into Asia on their own. In most cases, Japanese firms are either establishing subsidiary operations or expanding the role of their existing companies. The objectives are often quite complementary in that they may transfer manufacturing technology to their Asian locations at the same time they are bolstering the local economies. The fact that Asia as a marketplace for Japanese products is growing faster than any other part of the world is not lost on the Japanese firms. They get the advantage of shifting trade and exports from Japan to the Asian NICS at the same time they assist in developing the demand for their products, from consumer electronics and appliances to heavy equipment and communications systems.

One of the MITI goals is to transform Japan from the "manufacturer of the world" to the "laboratory of the world." The Japanese are establishing their business, telecommunications, and computer standards in the Asian countries as they expand commercially and provide ODA funds. Given the lack of funds available to the developing countries of Asia other than from Japan, it is clear that the financial and technological influence of Japan in the region will continue to grow.

#### TECHNOLOGY TRENDS -- MOS DRAM DENSITY

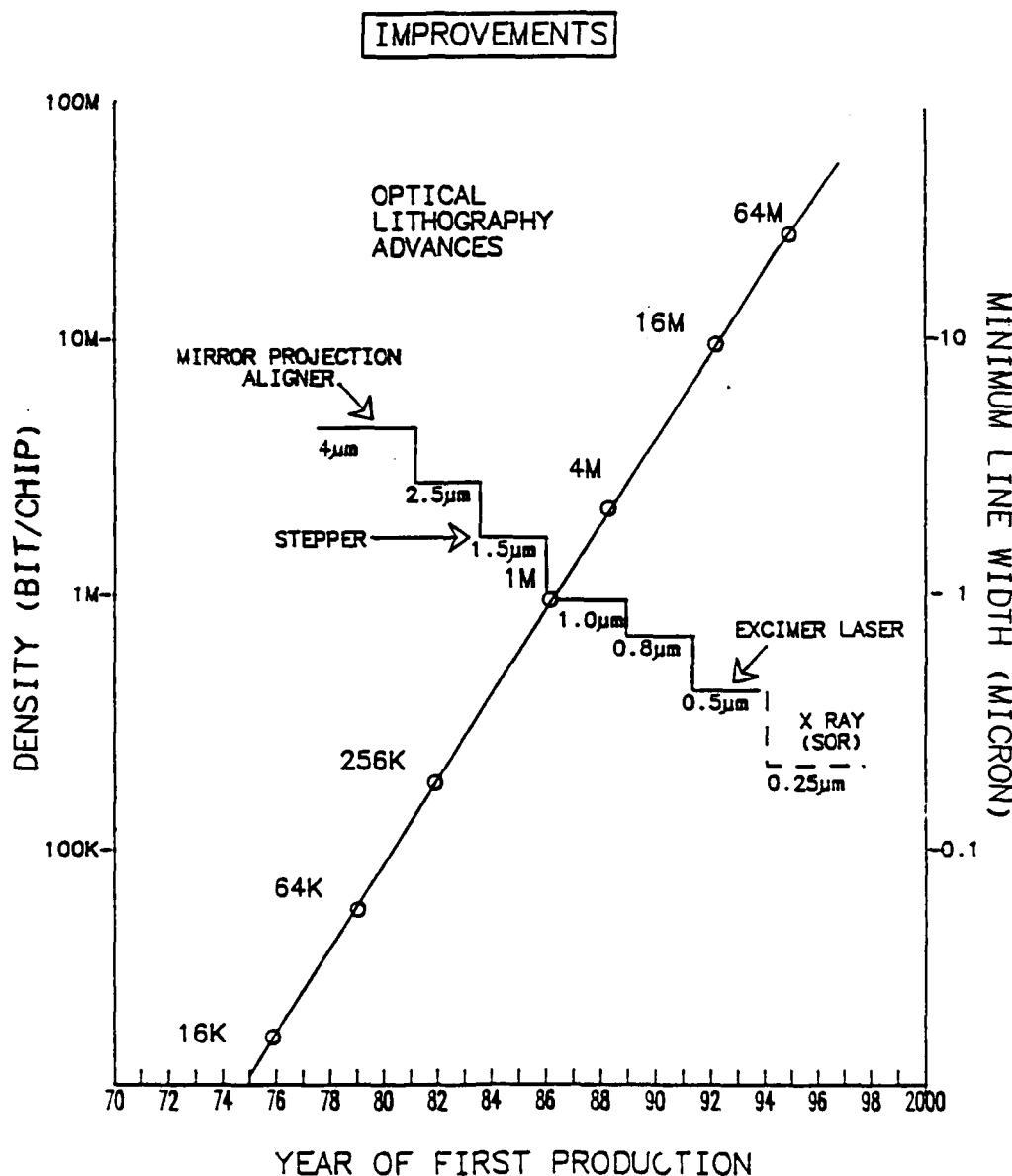
Although the Japanese are considered to be the leaders in memory DRAM production and development, they recognize that significant advances are required if they are to meet the price performance improvements required to meet industry needs as defined in the MITI 2000 report. The next graph shows the historical advances in photo lithography technology that led to increased DRAM density and the need for breakthroughs in technology required to achieve the 64 million bit chip in the future. As was mentioned in the section on basic research incentives, the government has sponsored the development of synchrotron orbital radiation technology required to reduce the line width to 0.25 microns. This recognition of the interdependence on tools and techniques required to remain competitive on a global scale is quite characteristic of MITI and the industry in Japan.

#### TECHNOLOGY TRENDS -- PROCESSOR SPEED

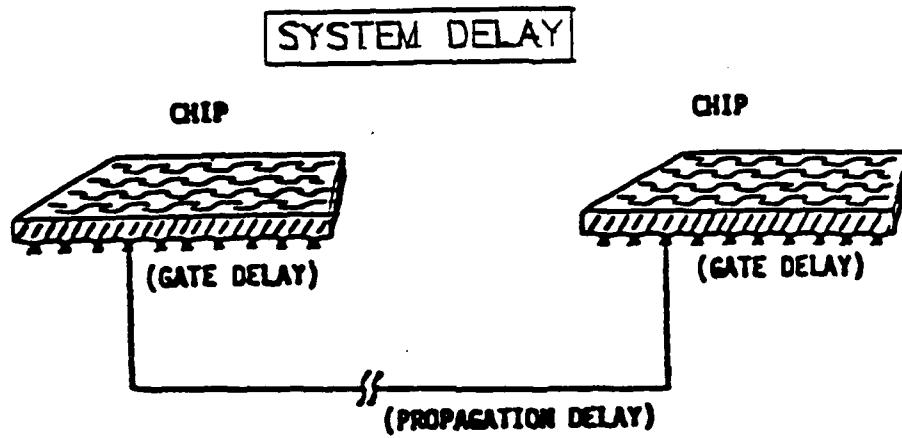
The second chart shows that recent advances in packaging technology have been the main reason for the dramatic improvements in processor speed and that advances in the speed of chips themselves are now required. Advances in the slower, but cooler, CMOS chips have come a long way in the past few years, which has allowed the production of low cost and high capacity processors even though they may not be as small as the faster, and hotter, BIPOLE logic chips.

A related graph shows that gallium arsenide may be the material that provides the breakthrough needed in logic technology for the near future. The Japanese have made a commercial success out of gallium arsenide chips, using them in satellite communications applications. There are now more than 700,000 personal satellite communications receivers in Japan that use the gallium arsenide chip technology. This is impressive in that there is only one NHK satellite and it has been in operation for just over a year, transmitting commercial television programming.

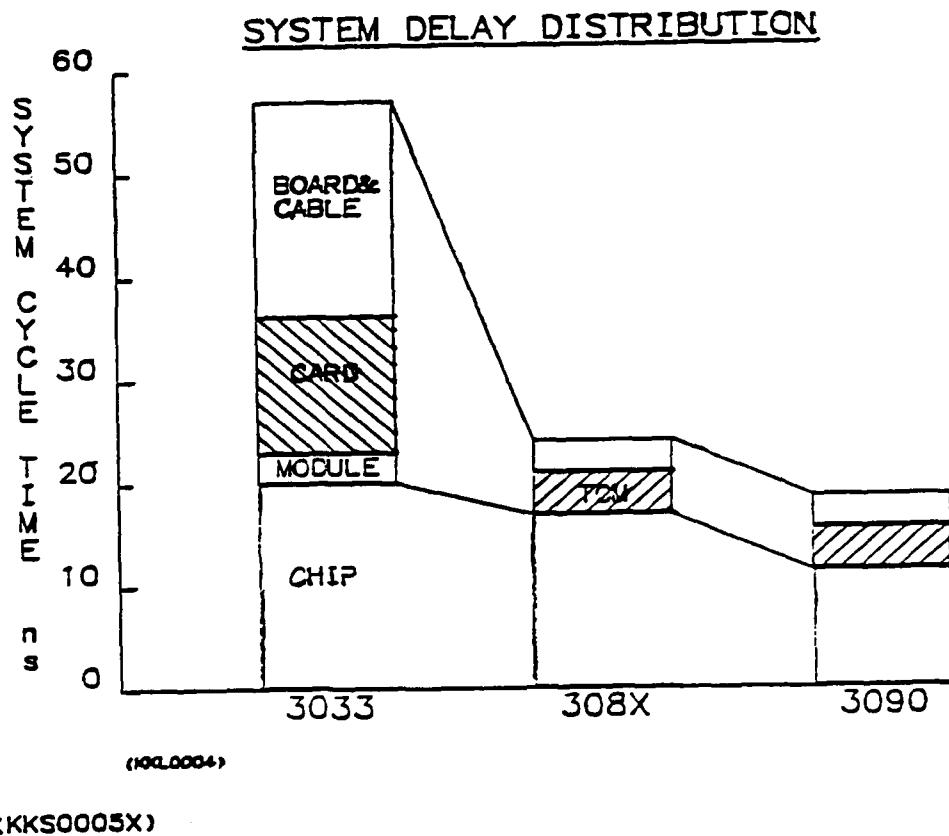
## TECHNOLOGY TRENDS - MOS DRAM DENSITY



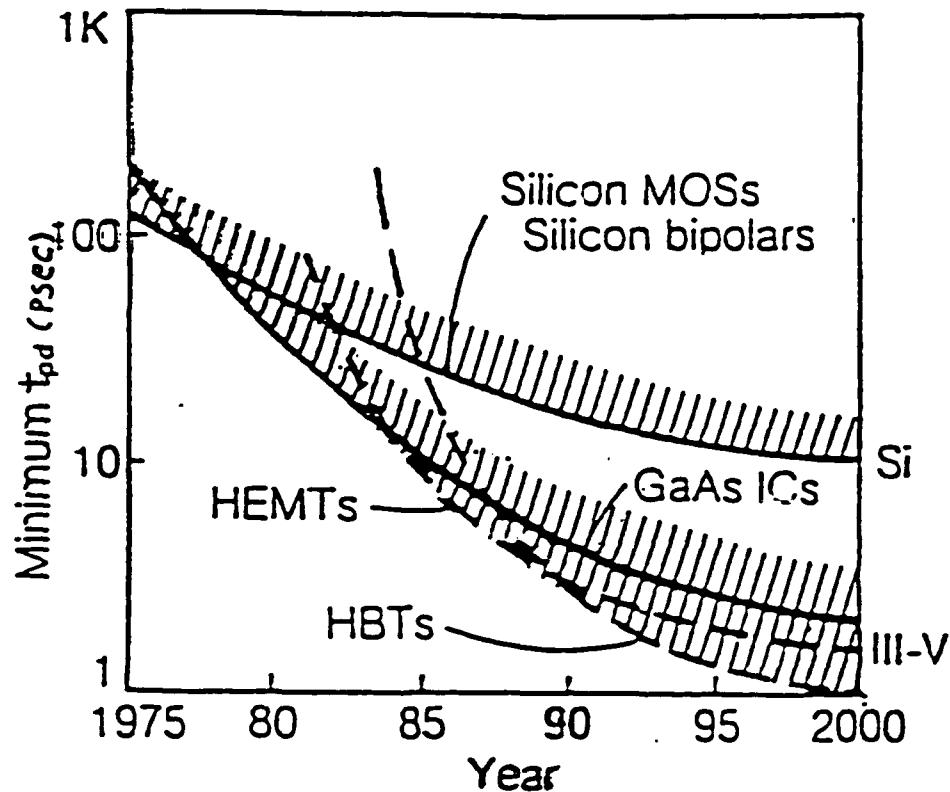
## TECHNOLOGY TRENDS - PROCESSOR SPEED



DELAY TIME = GATE DELAY TIME + PROPAGATION DELAY TIME  
(Sub-ns/gate) (0.07-0.10 ns/cm)



## GaAs SEMICONDUCTOR

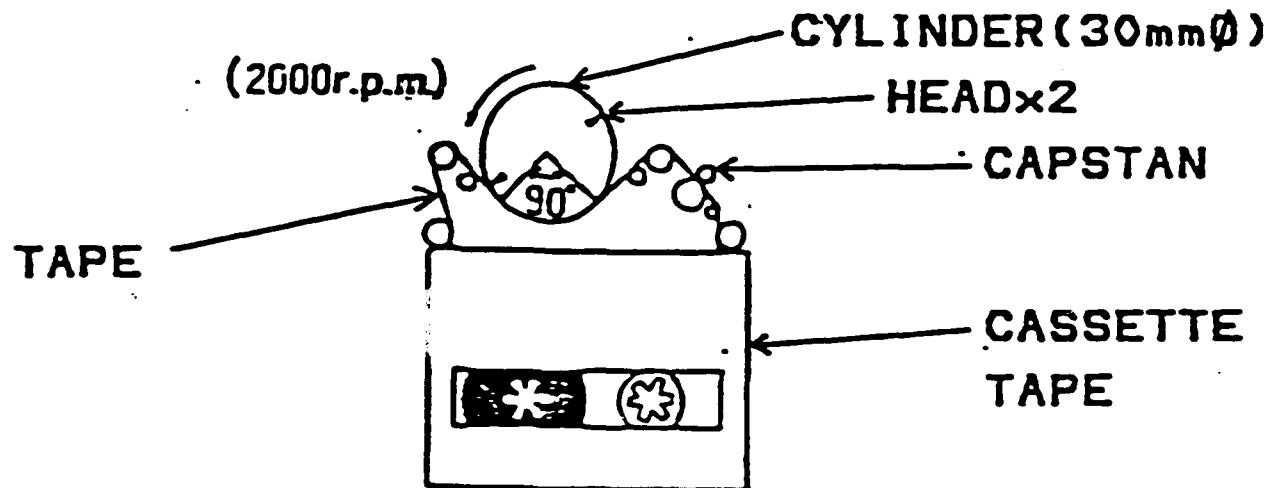


- HIGHER MOBILITY

$8000 \text{ cm}^2/\text{V/sec.}$  ; Si  $\times 5-6$

- LOWER POWER DISSIPATION

## DIGITAL AUDIO TAPE (DAT)



## R-DAT

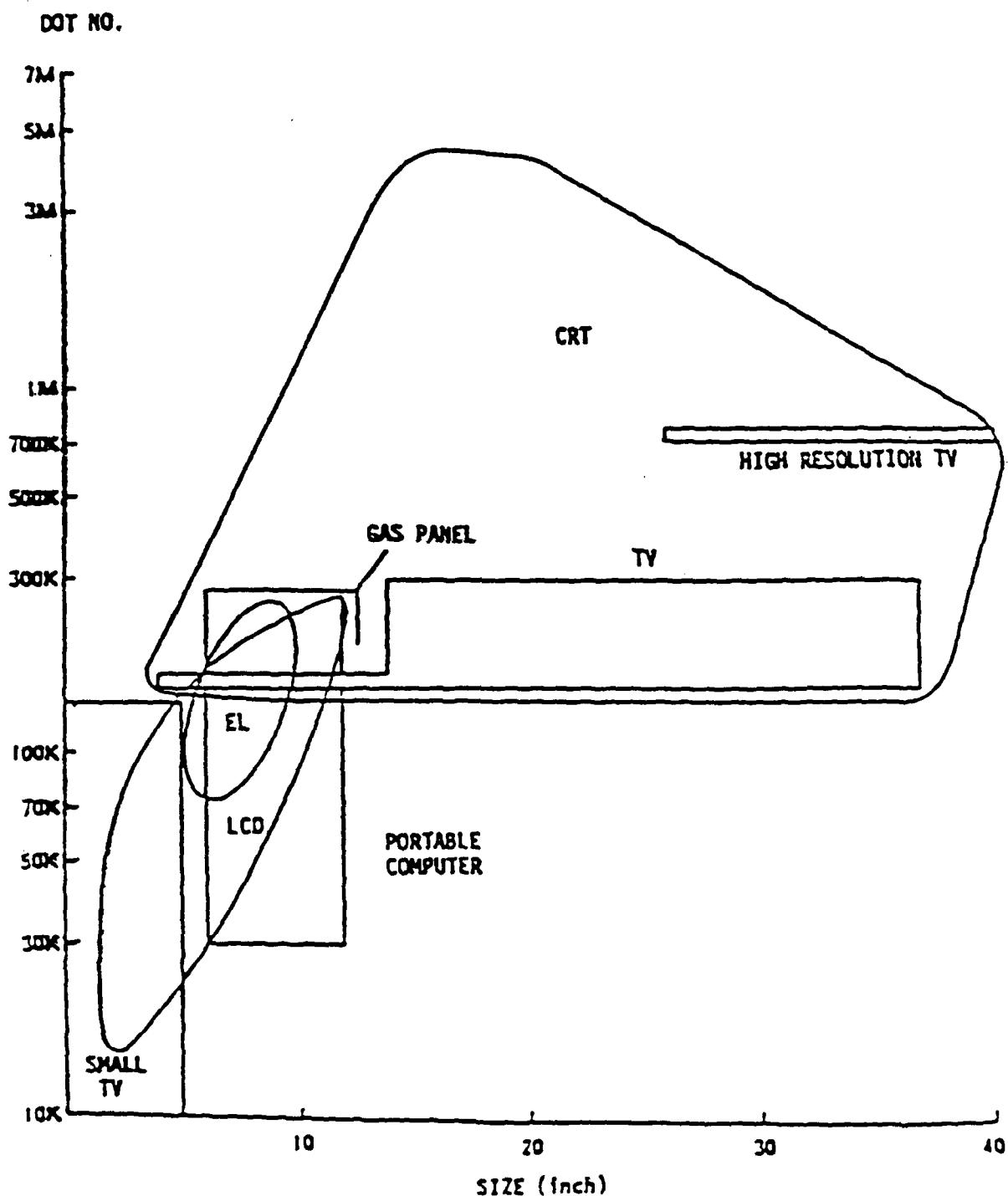
### CHARACTERISTICS

. SCAN METHOD	: HELICAL (ROTARY DAT)
. MEDIA	: METAL POWDER
. HEAD	: AMORPHOUS CoZr OR SENDUST
. TAPE SPEED	: 8.15mm/sec.
. CAPACITY	: APPROX. 1 GB
. CASSETTE SIZE	: 73x54x10.5 (mm)
. SAMPLING FREQUENCY	: 48K Hz
. QUANTUM LEVEL	: 16 BITS

### STATUS

. ANN'T	: 1987
. No. OF MFRS	: 19

## DISPLAY TECHNOLOGY

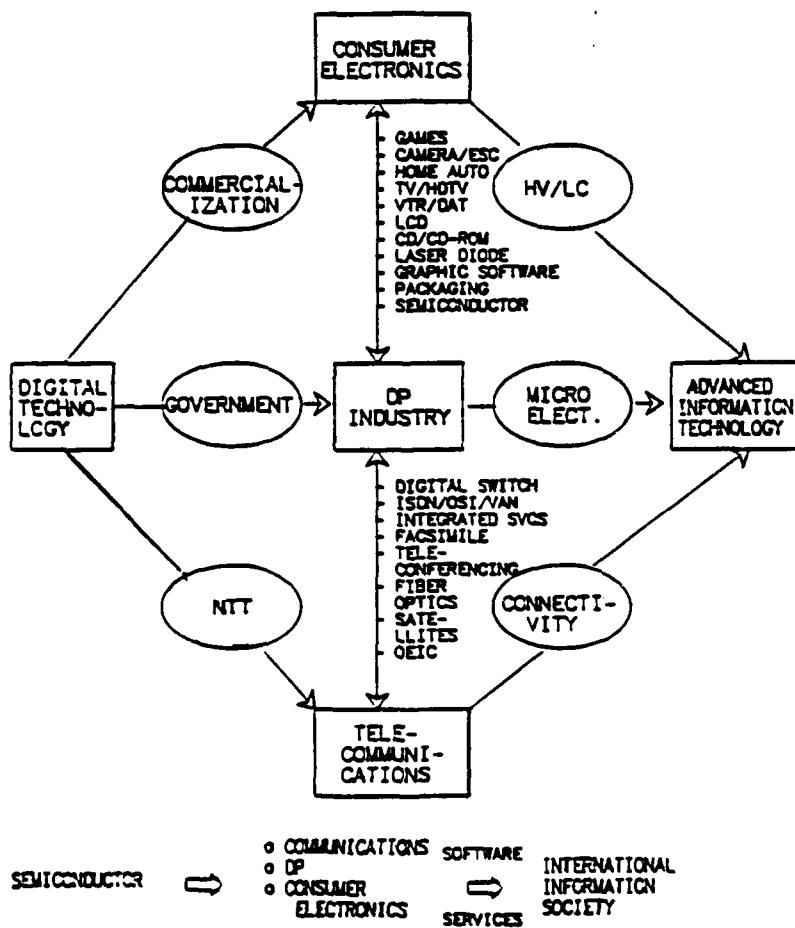


## TECHNOLOGY TRENDS -- COMMERCIALIZATION

The most significant aspect of the development of technology in Japan is the synergistic effect that consumer electronics, data processing, and telecommunications have in providing the building blocks for the information society of the future. Nippon Telegraph and Telephone Corporation (NTT) has played a key role in providing consistent funding via procurements from the key Japanese computer manufacturers and has stimulated the integration of the data processing and telecommunications industries.

The trend in technology is to develop products and technologies that have applicability to a variety of segments. The high-volume, low-cost factor of consumer electronics will make such technologies as digital audio tape, compact disks, high definition television, and laser diodes applicable across the three industries. The value of this reduction in costs is key to the rapid expansion of data processing and telecommunications industries in the future.

### SYNERGISM



## MILITARY TECHNOLOGY TRANSFER

This section describes the available government-to-government agreements that allow the transfer of military technology between Japan and the U.S.

As background, there are restrictions through article 9 of the constitution of Japan which limit the Japanese military forces to a self-defense role. A budget cap for annual expenditures of no more than 1% of GNP was removed from the FY 88 budget. However, a predominant view is that the Diet will always informally restrict the defense budget; in fact, the FY 88 defense budget was approved at approximately 1.013% of GNP. Until a 1983 exchange of notes between Japan and the U.S., the Japanese law did not allow export of military technology.

Various categories of cooperation do exist, from Foreign Military Sales (FMS) to Japan, with licensed production, to Data Exchange Agreements (DEA) between the military research communities. The Nunn Amendment (and subsequent Quayle amendment) were passed to encourage investment in "emerging technologies and modernized production facilities" and "to improve cooperation in research, development and production of military equipment" among friendly foreign nations.

Each of the existing categories of cooperation is discussed.

### CATEGORIES OF COOPERATION

- I. Licensed Dev/Prod (FMS)
- II. Memo of Understanding
- III. Data Exchange Agreements
- IV. Japanese Military Technology Transfer
- V. Nunn (Quayle) Amendment

### LICENSED DEVELOPMENT/PRODUCTION

This is the most mature category of cooperative agreements. It covers technology transfer from the U.S. to Japan and has been utilized, to date, only for licensed production.

In addition to the examples listed, the newest program, the FSX fighter program, is both licensed development and licensed production.

- o Total weapons systems oriented
- o Self-defense oriented
- o Co-production emphasis
- o Examples

F-14	MARK 46
P-3	STINGER
AH2S	TOW
CH47J	HAWK
	PATRIOT

#### MEMORANDUM OF UNDERSTANDING

Although only two projects, to date, fall into this category, it is an important mechanism to allow Japanese participation in U.S. projects.

- o Projects
  - "Western Pacific Missile Defense Architecture-SDI"
  - "Space Station" - NASA

### DATA EXCHANGE AGREEMENTS (DEA)

This category is for "information only" exchange between the research communities of the U.S. military services, as well as DoD, and the corresponding Japanese agencies plus Japanese industry through the agencies. The DEA procedure is similar in concept to the Great Britain, Commonwealth IEPs. There are approximately 45 DEAs today. There is, however, a view that improvements could be made with a more critical focus and coordination between research groups.

- o Information Only
- o U.S.-Japan
- o Intra-defense research community
- o Procedures to reduce administrative delays
- o Allows classified exchange
- o Like Commonwealth IEPs
- o Mixed focus (judgment)
- o Approximately 45 to date
  - "Laser Technology"
  - "Screening Smoke"
  - "Aerosol Technology"
  - Small Arms
  - "Combustion Technology"
  - "Anti-Surface Torpedo"
  - "ASW Detection Equipment"
  - "Countermines"

### JAPANESE MILITARY TECHNOLOGY TRANSFER

This most important category of cooperative agreement officially provides for export of Japanese military technology to the U.S.

In a DDR&E memorandum to the military services, February 1986, the importance was stated as:

"Technology and armaments cooperation with Japan has, for many years, meant the flow of U.S. defense technology to Japan to permit their production of military equipment of our design. The consequences have been improvements in Japanese forces, standardization of equipment with our forces, and the enhancement of Japan's industrial base. It is time to give equal attention to developing and realizing transfer from Japan to the U.S. . . . "

Very explicit categories listed are designated below. It should be noted, however, that commercial, or dual use, technology is not covered by this agreement. It is stated that commercial technology is available from Japanese private industry.

Although this agreement has a broad base, it is a view from the professionals involved that Japan has been conservative in making initiatives. Very recently, five new initiatives have been offered and are under assessment: (underlined)

- o Ducted rocket
- o Ship degaussing
- o Laser countermeasures
- o Dual technology seeker
- o Kinetic energy and shaped charge anti-armor projectiles
- o Firearms
- o Ammunition
- o Explosives
- o Explosive stabilizers
- o Military vehicles
- o Military aircraft
- o Anti-submarine/torpedo nets
- o Armor plates
- o Military searchlights
- o Bacterial/chemical/radioactive agents

#### SUMMARY

#### JAPANESE TECHNOLOGY TRANSFER

One judgment regarding this important source of technology is that agreements in place are adequate. The results, however, are far from satisfactory. Certainly the Japanese government needs to be more highly motivated to propose meaningful initiatives for significant benefits to be achieved.

A greater focus on critical technologies -- military and commercial -- plus a more organized DoD effort, with changes to the current proposal and request process, could achieve improvements. Additional U.S. government/DoD staffing, in Japan, would pay dividends in accelerating data exchanges and technology transfer. A major difficulty is also the language translation delays. This was a prior DSB Study recommendation.

Finally, it should be noted that cooperation does exist, and has been expanding, since the start in 1978 of a twice yearly Japan/U.S. Science and Technology Forum. The new initiatives by the Japanese government are encouraging.

The recent successful negotiation of the MOU for the co-development of the Japanese FSX based on the F-16 airframe, and the five projects proposed by Japan for cooperative development, may be significant. In addition, the Japanese are seriously considering the U.S. DoD proposal for initiation of a scientist and engineering exchange program.

It is felt that the recent visit and attention by the U.S. SECDEF was important to priority setting, and should be followed by additional emphasis and collaboration at the OUSD(A) and service levels in the U.S. The resulting technology transfer will pay for the investment.



### III.

## The Technology Base

### BACKGROUND

The importance to national security of the scientific and technology capability of the United States cannot be overstated. The Department of Defense Technology Base program is intended to ready the nation's technology for incorporation into the operational inventory of our forces. The Technology Base program both adapts dual-use technologies and develops defense-specific technologies. The objective is to substantially increase our defense capability at the lowest possible cost.

For the purpose of this report, the DoD Technology Base is defined as those programs in budget categories 6.1 and 6.2. The DoD Science and Technology program includes the Technology Base and the 6.3A budget category. The 6.3A programs are critical because they both demonstrate technology and insert technology into defense systems. In addition to the service 6.3A programs, this category includes programs such as SDI, NASP, BTI, VHSIC, and MIMIC. Because the numerous definitions of the national technology efforts frequently cause confusion, we list the definitions of terms used in this report in Table III-1. In this report, we address the DoD Technology Infrastructure in total, although specific oversight and advocacy issues of IR&D are discussed in another section.

TABLE III-1  
Definitions of Technology Efforts

<u>Name</u>	<u>Budget Categories</u>
DoD Technology Base	DoD 6.1, 6.2
DoD Science and Technology Program	DoD 6.1, 6.2, 6.3A
DoD Technology Infrastructure	DoD 6.1, 6.2, 6.3A, IR&D
National Security Technology Base	DoD 6.1, 6.2, 6.3A, IR&D Other agencies' programs, including DOE, NSF.
National Technology Base	All federal (military and civilian) R&D and Industry R&D

Support of the DoD Technology Infrastructure is best demonstrated by examining some historical trends in funding. First, Figure III-1 shows significant erosion of funding in the 6.1 and 6.2 categories since the 1960s. There was a short-term upswing in the early 80s, followed by erosion after 1985. The recent historical trend in Science and Technology funding is shown in Figure III-2, where the only significant increase has been for SDI. Finally, Figure III-3 compares the Technology Base funding to Gross National Product (GNP), research in the U.S., and federally supported research over the past three decades. The figures clearly show that Defense Technology Base funding has eroded significantly relative to our national economy and other research. For completeness, actual budget numbers for recent years are shown in Table III-2.

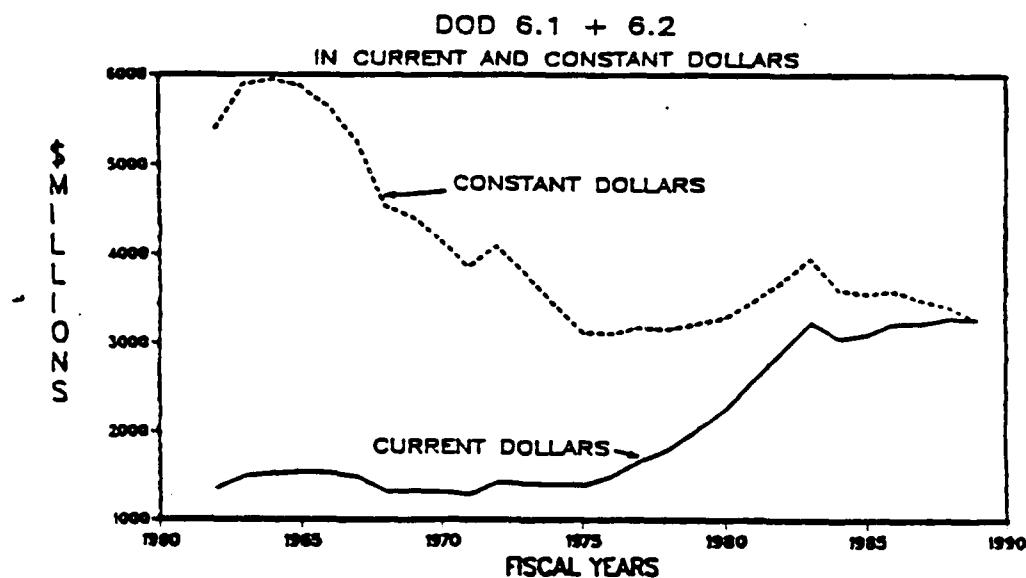


Figure III-1. DoD Technology Base Trend

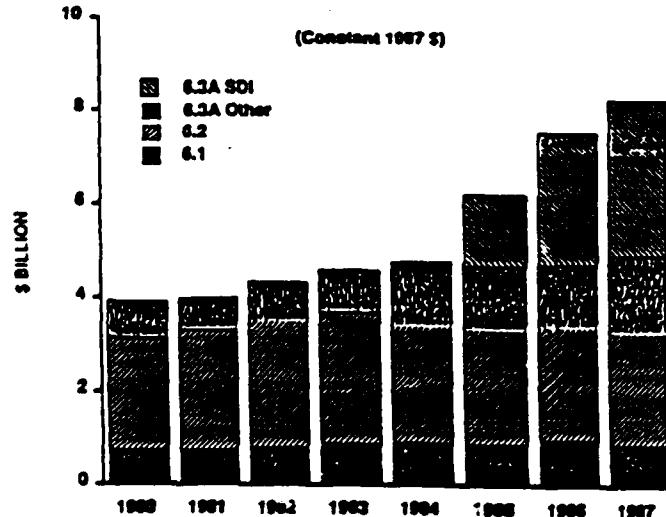
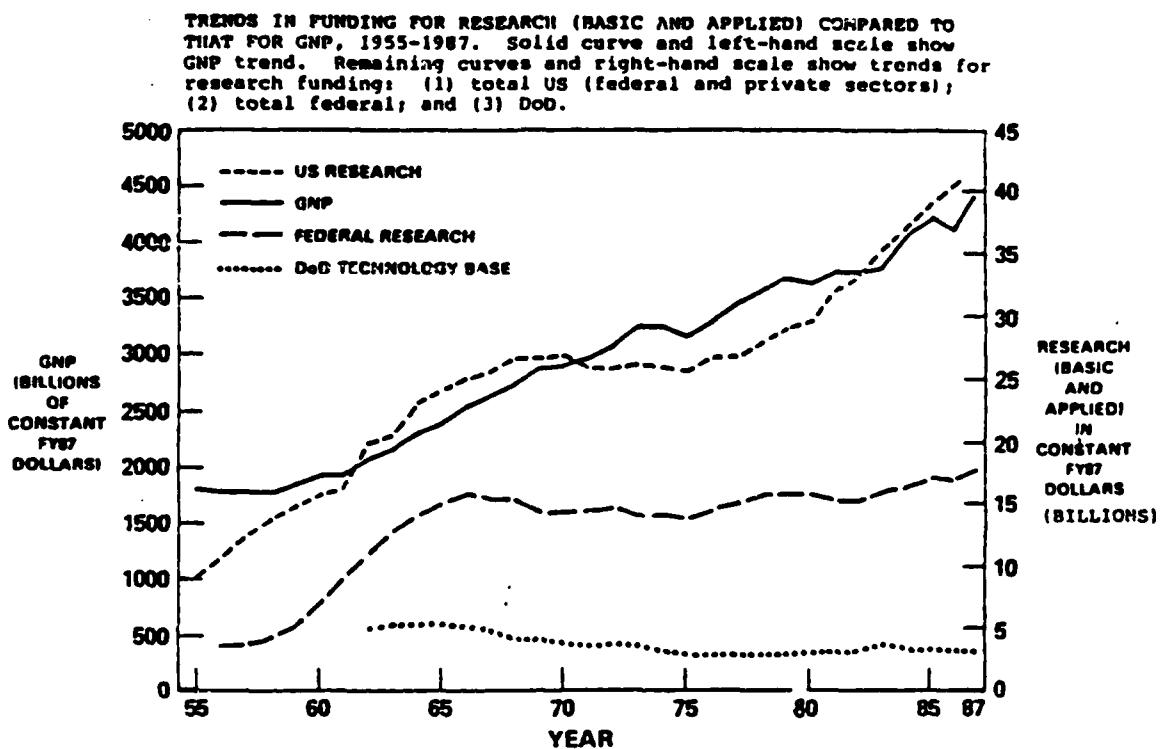


Figure III-2. Science and Technology Funding



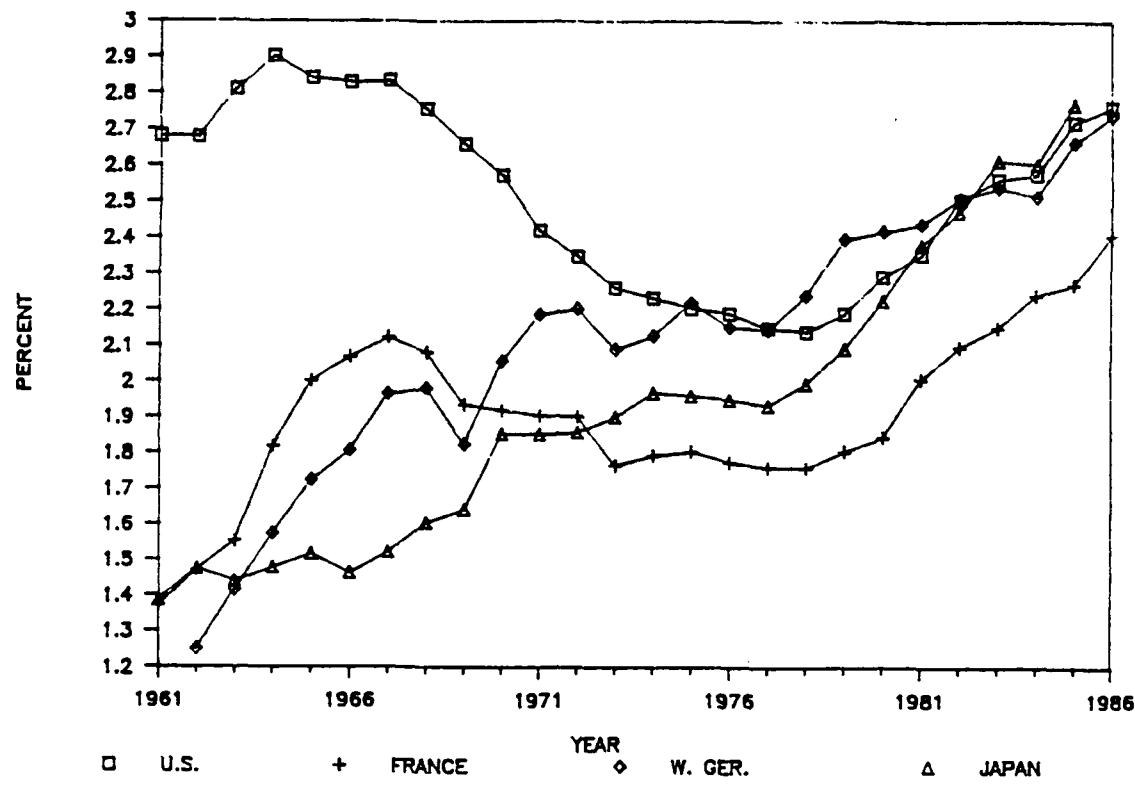
SOURCE: OSD/DUSD(R&AT)

Figure III-3. Trends in Funding for Research (Basic and Applied) Compared to that for GNP, 1955-1987

Table III-2  
Science and Technology Base Funding

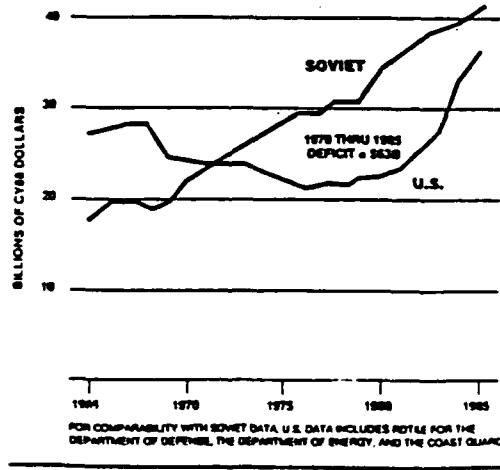
	1986 (\$M)	1987 (\$M)	1988 (\$M)
Technology			
6.1 Base	954	894	901
6.2	2279	2343	2392
(w/o SDI)	1403	1772	1903
(SDI alone - 6.3A)	<u>2662</u>	<u>3260</u>	<u>3531</u>
TOTAL	7298	8269	8727
<u>Industry IR&amp;D Plus B&amp;P</u>			
	1986 (\$M)	1987 (\$M)	1988 (\$M)
Industry IRAD + B&P Expenditures	7491	7263	
Allowable Ceiling	5277	5346	5634
DoD Share of Costs	3547	3619	

Figures III-4 and III-5 compare the total historical R&D funding of the U.S. with other major industrial countries and with the Soviet Union.



SOURCE: NSF SCIENCE & ENGINEERING INDICATORS - 1987

**Figure III-4. National Technology Base Funding as a Percent of GNP**



SOURCE: DISCRIMINATE DETERRENCE, JAN. 1988

**Figure III-5. U.S. vs. Soviet Military Research, Development, Test, and Evaluation**

Figures III-1 through III-5 show that, both nationally and militarily, the country has not sustained a strong long-term commitment to R&D when compared to other nations, particularly the Soviet Union. In part, that is what this study is about. "How do we maintain a national commitment to technological and economic strength?"

While the level of funding is important, effective use of these resources is even more important. Research must be conducted by the appropriate talent sector to assure both generation of new concepts and insertion into defense systems. For FY87, the distribution of R&D budgets by performer is shown in Figure III-6. As expected, the principal performers of basic research are universities; in applied research, it is industry.

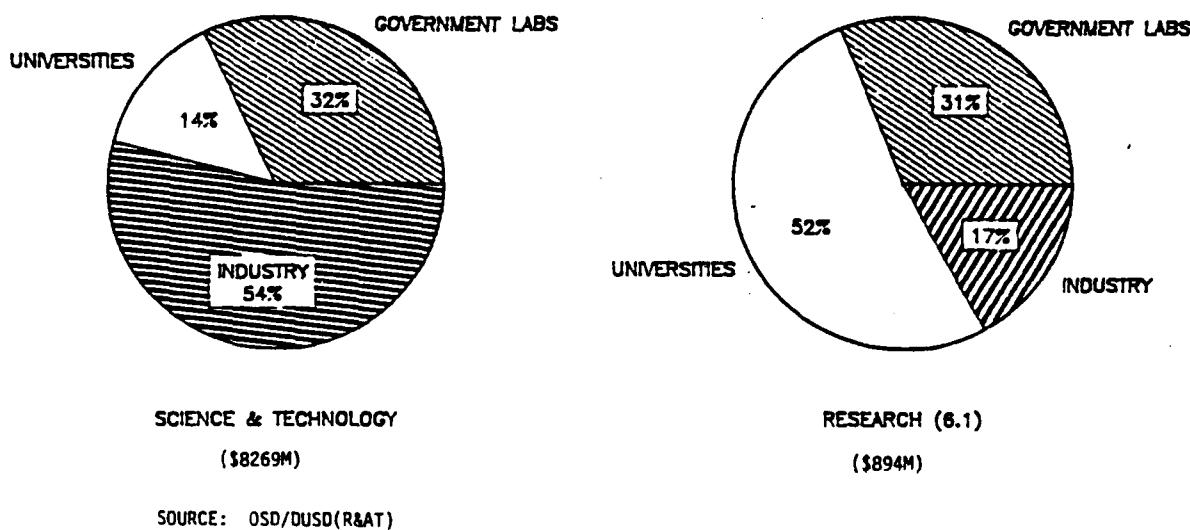


FIGURE III-6 Performers of DoD R&D (FY 87 Estimates)

The 1987 DSB Summer Study highlighted the need to more aggressively demonstrate and insert technology into defense systems. More effective links between basic research and the industrial development of defense systems are needed. Industry performs about \$150 M of the DoD-funded basic research. The only other mechanism for basic research funding in industry is through IR&D, and only a small fraction of IR&D is devoted to basic research.

Although IR&D is the subject of another section of this report, it is a critical component of the technology infrastructure (6.1, 6.2, 6.3A, and IR&D). Since IR&D is resident in the industry that uses it, the typical hurdles associated with technology transition, i.e., understanding, advocacy, and "not invented here" are automatically eliminated. IR&D is the most effective mechanism for developing and inserting technology into defense

systems. The recent levels of IR&D plus B&P expenditures and reimbursement are shown in Table III-2. In recent years, the emphasis on increased competition has resulted in B&P expenditures growing to be 35% of the IR&D/B&P total.

All of these factors illustrate the continual pressures on the DoD technology infrastructure: the difficulty in maintaining a long-term vision at the expense of short-term requirements, the pressures to assure a balance within the infrastructure among performing segments, and the need to assure that the segments are effectively transferring their research products to each other.

Because the role and goals of the science and technology infrastructure are often misunderstood, they are restated here. Technology gives defense systems new capabilities; therefore, the Department of Defense uses technology as a force multiplier. While this is a concept that is universally accepted, many people do not realize or understand that a second goal is to reduce costs. Many programs in the science and technology infrastructure are there to make an existing capability affordable. Example programs include VHSIC, MIMIC, STARS/Ada and many materials processing programs. Such programs are designed to reduce both initial system cost and life cycle costs through increased reliability and lower maintenance. In addition, there are those who think that the only technologies designed to reduce manufacturing costs are in the ManTech programs. This is not accurate; for example, robotics is strongly funded outside ManTech, as is automatic target recognition, which is very synergistic with robotics.

Therefore, we reassert that the goal of the DoD Science and Technology infrastructure is to provide the best military capability to defense systems at the lowest possible costs.

There have been numerous studies of the Defense Technology Base, some of which are listed in the bibliography. Most of these studies identify the same key issues in establishing and exploiting a strong technology base. They can be summarized as follows:

- 1) People. First and foremost! The quality of the scientists, engineers, and managers in the program is critical to its success.

Effective leadership of the program (from the highest levels of OSD and the services) and effective execution of the program (at the lower levels in the agencies and services) is totally dependent on the qualifications, vision, and capability of the personnel in the program. There have been numerous recommendations in the past to improve the personnel system. Until the problems within the system are addressed and corrected, there is little hope in solving most of the following problems.

- 2) Resources. Budget stability and modern laboratory facilities are necessary to a productive technology base program.

Planners under the pressure of short-term budget requirements have difficulty in sustaining a commitment to technology base resources. Numerous recommendations have noted that only visionary policies from the highest levels of government tied to strong, effective, and persistent monitoring can assure adequate support for programs that support future needs as opposed to near-term requirements.

- 3) Technology Insertion. Products of the technology base are useful to defense only if they find their way into operational systems.

Left to their own devices, the technology community and the system acquisition community do not interface well; while, in fact, the technology base should be considered and managed as the front end of the acquisition process. Significant management attention and reliable mechanisms must be established to assure that system development programs effectively use the available technology. Also, scientists and engineers in the technology base need to continually review requirements with the user.

- 4) Management. The proper management structure, the establishment of clear lines of authority, and the retention of managers in positions long enough to establish accountability are essential to execution of the technology base programs. The quality of people, as identified in item number 1, is of fundamental importance, but they cannot function effectively if the management structure does not support them.

- 5) Technology. Finally, some of the past efforts have identified the technologies that are critical for future defense systems. Ideally, this is a continual process; however, on occasion, a major study effort has been useful in reflecting on the future.

The 1988 DSB study group proposes recommendations that are complementary, but somewhat different from the 1987 DSB Study on Technology Base Management. We note that the 1987 DSB Study is currently being implemented, and we encourage that process to continue. We are, however, disappointed that the Department has not fully responded to the key findings and recommendations of the numerous past technology base studies. Because the technology base is of great importance to national security and international economic competitiveness, it requires continued and aggressive attention.

### Recommendations

- 1) To ensure the vitality of the industrial and technological base, the Secretary of Defense should request that the President issue a Directive that establishes a Federal Government-wide Industrial and Technology Base policy.

The Issue: Establishing and sustaining a national policy for the protection and development of those portions of our industrial and technological base that support national security has been an elusive goal since the demobilization that occurred after World War II. The development of coherent policy is made difficult, if not impossible, by the vast and diverse nature of the national economy and by the conflicting needs to have an efficient peacetime defense base and at the same time one that has sufficient capacity to mobilize rapidly.

This problem is made more severe by the fact that many agencies of the Federal Government have jurisdiction over policies that bear on the industrial issues affecting national security. For example, one can expect to find that the President's Science Advisor may call for support of the technology base when the DoD cannot afford such support, or the State Department may advocate sharing technology with our allies while the DoD is protecting that same technology.

These naturally conflicting interests, coupled with the intense competition for federal funds, encourages resolution only of easy issues. Difficult issues, including some that are vital to the long-range security of the nation, remain unresolved.

Finally, a national security policy affecting the National Technology Base cannot be totally, or even predominantly, separated from the civilian economy of the nation. America's defense companies compete with their civilian counterparts and are integrated with them in the sharing of financial, personnel, and natural resources. Likewise, they compete in the international marketplace.

The Solution: No single federal agency can resolve this issue within its own resources. It requires a strong interagency cooperative effort to establish broad policy and to resolve interagency disputes. The agency charged with these tasks since 1949 has been the National Security Council (NSC). As an agency within the Executive Office of the President, the NSC has the broad perview needed to address the full scope of the problem and the direct connectivity to the President to resolve interagency disagreements. The draft Directive, attached as Appendix A, establishes the framework needed to begin the process of establishing and implementing a coherent national industrial policy in support of our national security interests.

- 2) In view of our inability to provide sufficient incentives to attract the best and the brightest scientists and engineers to government service, USD(A) should examine appropriate mechanisms for the private sector to provide, high quality technical talent for government laboratories, some RDT&E centers, and DARPA. USD(A) should propose a process to examine the feasibility and optimum organizational mix of government control and private sector support for each high technology R&D organization.

The capabilities of the technical talent focused on national security needs is without a doubt the most significant issue facing the technology infrastructure.

Over the past decade, many studies ([7], [11], [13]) have pointed to the need to improve the personnel system and increase the capability to hire and retain the highest quality scientists and engineers. The government bureaucracy has not been able to respond. It is time for the USD(A) to take positive, bold, aggressive action. The privatization of the high technology scientist and engineering work force offers that possibility.

The reliance on technological superiority for achieving deterrence is dependent on the competence of our defense laboratories. That competency in turn is mainly dependent on high quality scientists and engineers and adequate research funding. We strongly support the findings and recommendations of the 1987 DSB Summer Study which sought to improve the quality of research personnel. Specifically, the 1988 Study Group believes that the conversion of laboratories to Federally Funded Research Development Centers or similar institutions should be instituted on a selective basis and, further, that implementation be accomplished at no additional costs.

Although, the central contracting authority must reside with federal employees, the technical support of that activity can be provided by the private sector. Careful study is required to determine the feasibility and optimum mix of government and privatized structure for each organization. Appropriate guidelines must be considered to establish fixed -- probably lower than existing -- staff levels for each new organization so that the implementation is revenue neutral.

A privatized scientific workforce has served the Air Force well at two locations. ESD is supported by MITRE and Lincoln Laboratory, and AFSC/Space Division is supported by the Aerospace

Corporation. Similarly, the Department of Energy has had outstanding success with Lawrence Livermore, Los Alamos, Argonne, and Sandia Laboratories.

This recommendation is much more than a minor tweak of the system. It will broadly impact the way of doing business in other segments of DoD; but, in the long run, implementation of this strategy will have a strong positive impact on our nation's security.

3) USD(A), through DDR&E, should provide guidance and oversight for the DoD Technology Infrastructure.

a. Establish a strong integrated 6.1 basic research program. DDR&E should provide policy, guidance, and oversight of DoD basic research. Service and agency developed programs should be reviewed for content, quality, and relevance. DDR&E, in consultation with the services and agencies, should establish the DoD-wide budget level in basic research. The scope and budget levels of the individual service and agency programs should be defined and coordinated within each organization, emphasizing complementary efforts and controlling redundancy. Upon coordination and approval at the USD(A) level, the execution and management of the 6.1 basic research program should be fully delegated to the individual services and agencies.

The absence of a clear and defined central authority responsible for the scope and quality of the basic research program has led to budget instability and to strained relationships with the nation's universities. Universities are important to our national security goals both for their basic research and for their training of scientists and engineers. The USD(A) and the DDR&E must accept the responsibility and accountability for basic research and university relations.

b. Establish key technology clusters and a structure to provide oversight and guidance for funding and execution. Many critical technologies are relevant to more than one service. Examples are chemical defense, sensors, materials, automatic target recognition, environmental science, C<sup>3</sup>I, munitions, night vision and human factors. These technologies, and others, have been identified in an ongoing study by the Institute for Defense Analysis [4]. The IDA study is examining the feasibility of establishing technical coordinating panels (TCP) for these areas. We support this concept and believe that it should be considered by the USD(A) as a way to carry out his responsibility for management of the total technology infrastructure.

Technology clusters could be identified and TCPs created to perform periodic peer reviews of the technology content in the service and DoD agency programs. Each TCP would have high level representation from OSD, the services, and appropriate DoD agencies to ensure that the thrusts are properly focused and that there is synergism between the DoD funded research and industry-funded IR&D. To this end, each TCP would periodically review relevant products of the IR&D program to assure that the technologies are fully utilized across departments in determining priorities in the Technology Infrastructure.

In order to ensure that the most promising ideas are supported with an adequate funding level, we strongly recommend that a portion of the available funds be competed among the in-house laboratory proposals each year. The TCP peer review of these proposals should consider the balance between the work to be performed in-house and on contract with industry or other agencies. This type of competition may tend, over time, to identify lead laboratories for key technologies. For some technology areas, such as chemical defense, night vision and jet propulsion, this has already occurred quite naturally and without major controversy.

c. Reduce technology insertion barriers by implementing Advanced Technology Transition Demonstrations.

The technology insertion process is the process by which new technology is employed in new or upgraded defense systems. An effective insertion process can give the nation strategic advantage, measured both in comparatively better capability and years of technological lead time. The DoD needs to improve the quality of its technology insertion process.

The Advanced Technology Transition Demonstration (ATTI), defined in the 1987 DSB Summer Study [1], accelerates technology insertion. An ATTID is intended to reduce risk by providing "proof of principle" technology demonstrations, conducted at the system or major subsystem level in an operational --rather than a laboratory-- environment. The Board has defined ATTIDs, their implementation, and funding. Aggressive use of ATTIDs by DoD is still under consideration at this writing. This Study group reaffirms the recommendation to use ATTIDs.

d. Expand the annual report to cover the technological infrastructure.

Each year the USD(A) prepares a report describing the state of the U.S. defense technology program and a description of the proposed program for the following year. This report highlights achievements of the Science and Technology Program and identifies high leverage areas for ongoing research. It is the only document which integrates the entire U.S. Defense Science and Technology Program and provides a thoughtful perspective on the relative national importance of specific technologies.

However, not covered in this document is a key component of our technology infrastructure; namely, results and activities of the independent R&D (IR&D) program. Key achievements of the IR&D program are not communicated effectively, and the program has never been put in the perspective of our overall technology effort. This contributes to insufficient understanding and support of the IR&D program by high level budget administrators in the services, OSD, and the Congress. In effect, the program is an "orphan." The leadership of the services can readily measure its costs, but they have had no good basis for measuring its benefits, even though IR&D has demonstrably been effective in developing new technology for insertion. In fact, insertion has in some cases been accomplished very rapidly because the technology-developing industrial organization also performed insertion.

To redress this problem, we recommend that the USD(A) expand his annual report to include highlights of recent IR&D achievements and an assessment of their relevance to key defense goals. In addition, the report should include an assessment of the efficacy of insertion of technology in defense systems.

This Annual Report would then become the definitive document for the Technology Infrastructure, which includes DoD 6.1, 6.2, and 6.3A programs, as well as the IR&D program. DDR&E review and oversight of this total infrastructure will assure the needed synergy between DoD-managed programs and IR&D. The services already have at the working level strong interaction with the developments in the IR&D program. Therefore, what is needed is overall guidance and oversight by one high-level focal point in the Department, namely, the DDR&E.

## BIBLIOGRAPHY

1. Deutch, John. Defense Science Board Study on Technology Base Management. OUSD(A), December 1987
2. Key Technologies for the 1990's. Aerospace Industries Association of America, November 1987
3. Report of the Task Force for Improved Coordination of Science and Technology programs. Institute for Defense Analyses, June 24, 1988
4. The Defense technology Base: Introduction and Overview. OTA, March 1988
5. Augustine, Norman. Defense Science Board Task Force on Defense Semiconductor Dependency. OUSD(A), February 1987
6. Heilmeier, George. Defense science Board 1981 Summer Study Panel on Technology Base. OUSDRE(R&AT), November 1981
7. Packard, David. Federal Laboratory Review Panel. White House Science Council, May 1983
8. Hermann, Robert. USDRE Independent Review of DoD. USDRE, March 1982
9. Bennett, Ivan. Defense Science Board Task Force on University Responsiveness to National Security Requirements. January 1982
10. Bement, Arden. Report of the DoD Laboratory Management Task Force. July 1980
11. Institutional Barriers on DoD Laboratories. Senior Service Laboratory Representatives, October 1979
12. DeLauer, Richard. Defense Science Board Acquisition Cycle Task Force Report. March 1978



## APPENDIX A

### DRAFT PRESIDENTIAL DIRECTIVE THE NATIONAL INDUSTRIAL AND TECHNOLOGICAL BASE

Our national industrial base is critical to preserving the National Security of the United States. It must provide technologically superior defense material in quantities sufficient to meet our national security needs at reasonable cost, and do so in a timely manner.

A healthy, responsive, and technologically superior industrial base is an essential element in our national security strategy to deter war. It is also a prerequisite to sustaining our armed forces and ensuring that essential civilian needs are met during a national security emergency. Therefore, it is the policy of the United States to have an industrial capability that will ensure our continued prosperity and security.

A key part of our effort to enhance national security is the maintenance and improvement of our national industrial base. If the United States is to confidently face rapidly changing world conditions, American industry must have the capability to modernize and expand production to meet increased demands for weapon systems and supplies during times of national emergency. Our policies must recognize the vital part that industry plays in our capability to surge industrial production, and should foster improved relationships between the government and industry as partners in the support of our national defense.

The National Technology Base is the essential foundation of our national industrial base. The competitiveness of our national industrial base depends on a continuous creation and infusion of technology just as our national security relies on technology to give our military forces the capability to defeat adversaries who can muster numerically superior forces.

While all elements of our national technology base are important to national security, certain key elements of this base must be recognized as the cornerstone of our enduring national security strategy of deterrence. This national security technology base includes the science and technology programs of the DoD, the government-sponsored independent research and development program conducted by industry, the technology base program of the DoE, the technology base program of NASA, and the National Science Foundation program.

This directive recognizes the need to properly fund the national security technology base, even in times of relatively austere funding of other portions of the federal budget. Technology base

programs must have a high degree of stability so that long-term technology development programs typically not pursued in industry can be successfully integrated into weapon systems. Additionally, a rigorous, competitive, national security technology base program should be growing hand-in-hand with the commercial technology base in which it is embedded. Therefore, it will be the policy of this administration to fund the national security technology base program at a constant growth rate at least equal to the growth in our gross national product.

Even with this funding level, the success of this program will depend on its ability to successfully transfer technology to and from our own commercial technology base. The independent research and development program is the DoD's principal program which stimulates industry to develop innovative applications of technology to defense requirements. This program should be funded at a level commensurate with its importance to our national security.

New mechanisms within the government must be developed to ensure that these policies are implemented and integrated into our overall national security strategy.

This Directive provides for the creation of a national level forum to review and coordinate these critical policy issues which impact our national technological and industrial health. The National Security Council will coordinate the national security aspects of this activity by oversight of an Industrial Policy Committee (IPC) that will be established under the authority of this Directive. The IPC will be chaired by the President's National Security Advisor and will be comprised of appropriate representatives from the Departments of State, Defense, Justice, Commerce, Transportation, Energy, OMB, CIA, FEMA, NASA, and the NSF, with the President's Science advisor as a principal member. The IPC will also serve as a subcommittee of the Economic Policy Council (EPC). The IPC will have the ability to draw support from the entire array of government agencies and departments that comprise the EPC.

Goals that should be preeminent in developing a national industrial program development and in establishing a charter for the IPC include:

- o Review of major Government policies and their impact on the domestic industrial and technology base.
- o Review of Government policies as they relate to globalization of the industrial base.

- o Development of a plan for periodic industry-wide assessment of the rate of technology advancement and production capabilities compared to national security objectives.
- o Review of existing industrial policy objectives.
- o Redevelopment of a "key technologies strategy" that identifies those technologies where the country should be a leader or competitive to assure national security and economic competitiveness.
- o Review of the adequacy of resources dedicated to enhancing the national industrial and technological base, including independent research and development prior to the President's approval of his annual budget.
- o Review and revision of current executive orders, such as 11490 and 10480 that assign national security emergency responsibilities.
- o Development of industrial responses based on a graduated response to early warning.
- o Development of policies throughout the government that foster industrial innovation, modernization, and productivity.

This Committee will meet at least quarterly and prepare a summary of their activities, findings, and recommendations for review of the broader NSC and EPC membership, the President, and Congress as appropriate. The Committee will provide an annual report to the President on the strengths and weaknesses of the defense and commercial industrial base as it relates to national security. The report will identify the long-range impact of existing and anticipated government policies, laws, and regulations on the industrial base. It will make recommendations on changes to government policy needed to assure a national industrial base capable of sustaining national security objectives.

A4

**TECHNOLOGY BASE**

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## IV.

## Independent Research and Development

### EXECUTIVE SUMMARY

A robust defense technology base is essential to the viability of our national strategy of countering the threat's quantitative superiority with technological superiority. IR&D, through which the companies of the defense industry independently initiate, fund, and manage research projects which they believe will provide the advanced technology weapons required by our military services in the future, is essential to the health of the defense technology base.

Through IR&D, the DoD and the military services receive the benefit of the ideas of thousands of engineers in industry, and these ideas and IR&D results become available to the government's laboratories. IR&D enhances competition -- especially the important competition of ideas -- and improves the international competitiveness of the United States. DoD receives the benefit of about two dollars of industry expenditure on IR&D for each dollar of cost it bears.

IR&D and B&P increased sharply from 1980 through 1984, fairly closely tracking the DoD acquisition budget. From 1984 through 1987, while the defense budget continued to increase, IR&D/B&P declined slightly. During this period, B&P increased due to the pressures of increased demands for competition for military programs and, as a result, IR&D declined from \$5.2B to \$4.7B-- or about 10%. There is also evidence that IR&D has become more short term, risk-reduction oriented, as additional risks have been transferred to contractors.

Reduced DoD acquisition budgets and misunderstandings of the workings or value of the IR&D system have created recent pressures for significant reductions in IR&D/B&P ceilings. Other pressures on contractor profits from "procurement reform" actions of the past few years will make it impractical for contractors to do other than reduce their IR&D/B&P spending in response to ceiling reductions. This is documented in the 1987 study by the MAC group.

Reductions in contractor IR&D spending can have serious future impact on our ability to provide our military with the technically superior weapons they require. A contractor's spending is influenced chiefly by his IR&D/B&P ceiling level and the profit-

ability of his business. DoD controls the ceiling level and, through its procurement policy, greatly influences contractor profitability. Consequently, the decision as to the desired level of contractor IR&D/B&P spending should be made at the highest policy levels within DoD, and ceilings should be established at levels appropriate to bring about the desired level of contractor spending.

While the IR&D cost recovery system is imperfect, it is far superior to the alternatives of direct contracting or grants, and it should therefore be preserved. Inequities in the administration of the system by the individual services should be corrected by guidance and control from OUSD(A).

#### INTRODUCTION

Independent Research and Development (IR&D) consists of the research and development that companies themselves initiate, fund and manage. IR&D differs from that research and development work performed under contract in which the statement of work is specified by DoD. IR&D is each company's discretionary investment in those technologies and products that potentially will provide the most technologically advanced systems needed to sustain the U.S. deterrent capability and, if deterrence fails, to defeat an adversary. Recognition of IR&D as a normal cost on defense industry contracts has been debated for years, with the issues primarily focused on industry cost recovery and government controls. The debate has now taken on a new dimension as defense technology and commercial technology lines blur, and as American industry faces a major competitive challenge in an increasingly globalized economy.

#### BENEFITS OF IR&D

America has chosen to provide its national defense through deterrence. A key to the credibility of our deterrent capability is the ability to deploy technologically superior forces to oppose and defeat numerically superior enemies. The alternative, to meet numbers with numbers, has been rejected because of the economic and social costs. In order to maintain a credible conventional or nuclear deterrent, the evolution of military technologies and their timely application to defense systems must continue at an equal or greater rate than the evolution of the threat. The requirements process, where concepts for systems to meet the threat are derived, has been characterized by the Packard Commission as a combination of "technology push" and "requirements pull." In one respect, our military identifies threats which it must be able to defeat and seeks the technology necessary to the solution. In another, industry's new ideas, developed through IR&D, are offered as possible solutions to

current or projected problems. In both of these concepts, independent research and development helps DoD perform its principal task of providing for the nation's defense.

The strategy of using our technology to offset the advantages of a numerically superior enemy is generally accepted. An equally compelling argument can be made for using technology to our advantage in the kinds of conflicts in which we are more likely to become engaged, such as past actions in Libya or our continuing involvement in the Persian Gulf. Recognizing the consequences that result from captured or killed American military, and the absolute need to prevent injury or death to innocent civilians as a result of military action on our part, highly advanced technologies offer the opportunity to minimize these risks.

In the past, we have designed our systems based on a European war scenario and assumed that if the system was effective in Europe, it would surely be effective in a limited conflict scenario. This may not be a valid assumption. For example, highly accurate conventional cruise missiles are argued as being too costly to be procured in the large numbers necessary for a major war, yet they would be highly effective in limited numbers for use in the higher probability limited scenario. One can postulate a number of possibilities for stealth technology in these same limited scenarios. Thus, through IR&D, industry has provided the research base from which the country can better prepare itself for the risks it faces in the real world of today. When a military need is recognized in this scenario and a requirement is specified, industry is prepared to respond with a number of options for the military planner. In the final analysis, the National Command Authority is given greater latitude in establishing and implementing policies in a dangerous world.

The military's requirements for technical advancement are far reaching. Electronics, materials science, propulsion systems, and an almost unlimited variety of product and manufacturing technologies are essential to today's military systems. Of these requirements, only a portion can be pursued entirely through government directed and managed research and development. The remaining technologies have been pursued through industry initiated IR&D.

For our Armed Forces to remain competitive with the military threats we face, DoD must either pay to develop the specific answers itself, or enable others to do so for its benefit. Through IR&D, the DoD is provided access to the work of thousands of engineers and scientists in industry. This technology is not available under contracted programs. It is the expertise and judgment of these scientists and engineers which IR&D brings to bear on the challenges facing our Armed Forces. The RAND

Corporation, in its recent independent assessment of IR&D, confirmed that, in this way, IR&D increases the scale and diversity of available R&D.

In 1987, the defense industry spent \$7.3B in IR&D and related Bid and Proposal (B&P) costs. DoD's share of this expenditure is about \$3.6B. Critics of military spending question the rationale behind this \$3.6B DoD investment. For many years, both industry and DoD have struggled to articulate the benefits of IR&D which were intuitively obvious to them, but not obvious to some members of Congress or to the media.

For its 1987 investment of \$3.6 billion, the country benefitted directly and substantially through enhanced competition, technology transfer to DoD laboratories, and, on a better than dollar-for-dollar basis, more defense-related R&D than would have occurred without it. The RAND Corporation demonstrated that for every additional dollar of DoD investment in IR&D, industry spends two dollars, a 2:1 leverage of DoD dollars.

The value of IR&D in solving key military problems becomes evident long before contract proposals are sought. Decisions about improvements to existing systems and subsystems as well as decisions on the need for totally new systems are made, in part, on the basis of judgment and information available from intelligence and other sources. One of the greatest influences on the process is the list of competent technical solutions to the problem.

Industry spends IR&D funds in the areas in which it foresees future needs. If a new radar system must be designed to meet an evolving threat, companies seeking that business will pursue new developments in anticipation of future competition for systems to meet that threat. The same is true in every field, be it military or commercial.

Whenever our military forces generate a requirement, the competing technical solutions offered by industry provide DoD with options on the form as well as the details of the solution. These options give DoD the ability to choose the best technical solution within the budget constraints it faces. It is these options which are the product of IR&D.

The influence of IR&D on competition continues through the procurement and development cycle. Once the requirement has been defined, companies propose solutions that seek competitive advantage through technological differentiation. Further, each company's IR&D also leads to different approaches to design and manufacturing. Through IR&D, each company seeks a critical edge over the competition. This results in the best possible system at the best possible price for our servicemen and women, and the country maximizes the return on its defense investment.

One aspect of the IR&D process directly benefits the government's own research. Each year, as part of the IR&D cost recovery process, the government's laboratories undertake the technical review of contractors' IR&D proposals. These reviews give the government important and detailed insights into each contractor's IR&D efforts. Thus, the government evaluators learn about the broad spectrum of industry IR&D successes and failures. The description of ongoing work enables them to take the benefits of industry's work and include those benefits in their own R&D efforts.

The synergistic value of government and industry R&D is, perhaps, the greatest stimulus to technological advancement. Radical improvements rarely come from a single revolutionary discovery; rather, the great breakthroughs come from the combined effects of many innovations which, individually, may produce little or no progress. It is IR&D which ensures the steady production of these individual achievements and which provides a synergistic process which can lead to technological breakthroughs.

Given our American adherence to the free enterprise system, IR&D is critically important to our national defense posture based on a strategy of technological superiority. IR&D, in conjunction with the technological base portion of contracted R&D, has made a major contribution to our technological leadership in general. It is safe to say that IR&D is the lifeblood of technological growth in industries such as aerospace and electronics. There is little doubt that the first commercial jetliners and commercial jet engines were derived from R&D efforts of defense contractors. The same is true of infra-red sensors, the transistor, coherent radar, and the like. Furthermore, it is intuitively obvious that these have significant spin-off value in the commercial marketplace.

There are thousands of examples of IR&D accomplishments documented each year during DoD's technical evaluation of IR&D. Recently, well over one hundred specific examples have been summarized in "National Benefits of IR&D," published by the Aerospace Industries Association. This publication demonstrates the broad base of innovative ideas that flow from IR&D into defense systems and the advanced technologies developed under IR&D that form the defense technology base of the nation. These and other examples of the contributions of IR&D to national security appear time after time in critical aspects of our nation's best defense systems. Consider the following few examples:

<u>Defense System</u>	<u>Problems Solved by IR&amp;D</u>
Stinger Missile	Cadmium sulfide detectors, IR/UV rosette seeker, and re-programmable micro-processor resulting in 2.75-inch, man-portable shoulder-launched anti-aircraft missile.
C-17 Airlifter	Development of externally blown flaps for immediate availability of what would otherwise have been a long-lead technology item.
Missile Warning Radar System	New system which, regardless of direction of the attack and background clutter, automatically activates electronic countermeasures.
E-2C Hawkeye Advanced Associative Processing	Development of small, low-power system for automatic tracking of airborne targets.
AV8B Harrier	Met requirements for lightweight, small, portable flight line test set.
F-16 Fighting Falcon	Digital flight controls; new structural designs using superplastic formed aluminum.
Space Shuttle Orbiter	Investigation and identification of weather-resistant thermal protection system.
Pershing II Missile	Faster, cheaper, more reliable guidance with prestored reference data.
F-15E Eagle Advanced Radar	Incorporation of synthetic aperture radar mode, high capability programmable signal processor.
F/A-18A	Avoiding complexity, cost, and weight of variable sweep swing-wing leading edge extensions.
Aegis Fleet Air Defense System	Advancement of microelectronics technology to significantly enhance signal processing functions.
Poet Expendable Jammer	Creation of unusual electronics allowing an entire jammer to fit into a cylinder 4 inches long and 1-1/3 inches in diameter as part of a decoy.

IR&D also plays an important part in maintaining our competitive position in the world economy. In terms of international competitiveness, the steel and shipbuilding industries offer good lessons in terms of what can happen to industries that do not look to the future. Those industries became victims of technological decline. Foreign competitors became dominant because they were able to produce quality products at lower costs and sell them at lower prices than ours. Our electronics and aerospace industries -- although recognized as technologically advanced -- are now encountering similar competitive pressures from foreign producers. In recent testimony before the Senate Armed Services Committee, the Office of Technology Assessment stated that the U.S. is becoming increasingly dependent on foreign sources for defense technology. Action should be taken now with regard to those industries where we are technologically advanced to prevent costly, crisis management salvage attempts at some future time.

#### IR&D AND THE TECHNOLOGY BASE

A healthy, vigorous IR&D program is essential to maintain the cutting edge in those advanced technologies that make possible the technically superior weapons required to sustain American security.

From 1980 through 1984, IR&D and B&P increased sharply, tracking fairly closely the DoD acquisition budget. From 1984 through 1987, as a result of essentially constant IR&D/B&P ceilings and increased B&P spending, while the defense budget continued to increase, IR&D declined. IR&D and Bid and Proposal (B&P) costs are treated together for purposes of cost recovery on government contracts. B&P is a company's technical supporting effort involved in preparing and submitting proposals to the Government. DoD's focus on competition has forced industry to devote a larger percentage of its IR&D/B&P efforts to B&P. Second sourcing, multi-phased competitions, complex "super-team" procurements with leader-follower arrangements, and stretched source selection cycle times with multiple Best and Final Offers (BAFOs) all lead to increased B&P investments. As IR&D/B&P ceilings are reduced, industry tends to favor B&P efforts over longer term IR&D efforts in order to maintain its business base. The long-term, represented by IR&D, suffers.

DoD has not yet recognized that increased competition has resulted in reduced IR&D and has not developed a solution to sustain IR&D. The immediate solution may be to increase the ceiling, but other options may exist. It is highly improbable that DoD intended for increased competition to detract from the health of the technology base; and yet, that is exactly what is occurring.

In spite of its obvious importance to the Defense Technology base, decisions are now being made which could lead to a significant reduction in IR&D spending by industry. The arguments being made in support of those decisions stem mainly from misconceptions about the nature and the value of the IR&D program.

In addition to reduced IR&D, there is strong evidence that in recent years IR&D has become more focused on near-term risk reduction type efforts. DoD acquisition strategies have transferred substantially increased risk to contractors, mainly in the requirement to make early, large, and very long-term fixed-price commitments. While industry should assume a reasonable degree of risk, risk reduction becomes mandatory in the current environment and, in the longer term, the technology base suffers.

When IR&D investment decreases and becomes focused on the near term as well, industry's ability to pose competing technical solutions to the needs of the Armed Forces also declines. Industry is forced to use older, more conservative technological solutions to solve problems. Thus, fewer new solutions are available. Competition among companies becomes focused on price rather than technology. This creates a "low cost" culture which avoids risk and, contrary to our national strategy and historical practice, reduces the flow of technology from industry to DoD. The result is reduced technological superiority of U.S. systems over Soviet systems and a declining comparative advantage in international trade for U.S. high technology products.

Some critics of IR&D argue that IR&D is an industrial subsidy to large contractors and therefore acts as a barrier to the entry of smaller firms into the industry. Typical of the misunderstandings of the IR&D cost recovery process and the role of IR&D in competition is the following common argument:

- o That IR&D is "non-competitively awarded" mainly to the major DoD contractors therefore putting innovative small firms at a disadvantage and barring their entry into the defense business.

This is not correct. IR&D is not "awarded" to contractors. It is a category of normal business expense which is incurred by firms in the defense industry to develop the technologies and products its customers require. It is no different from R&D expense in commercial industries.

Furthermore, small firms are not at a disadvantage as a result of the IR&D process. Small firms can and do conduct independent research and recover costs just as larger firms do. In fact, small contractors have an advantage, since ceilings for companies that fall below the \$4.4M cost recovery threshold are established by formula rather than by negotiation. Figure IV-1 shows the

ceilings actually negotiated with the major defense contractors since 1980 compared to what the ceilings would have been if they were based on the formula used for smaller contractors. The formula applied to small contractors gives them a cost recovery advantage over large contractors who must negotiate ceiling agreements. A newcomer to the defense market may have difficulties, but the IR&D cost recovery process is not one of them.

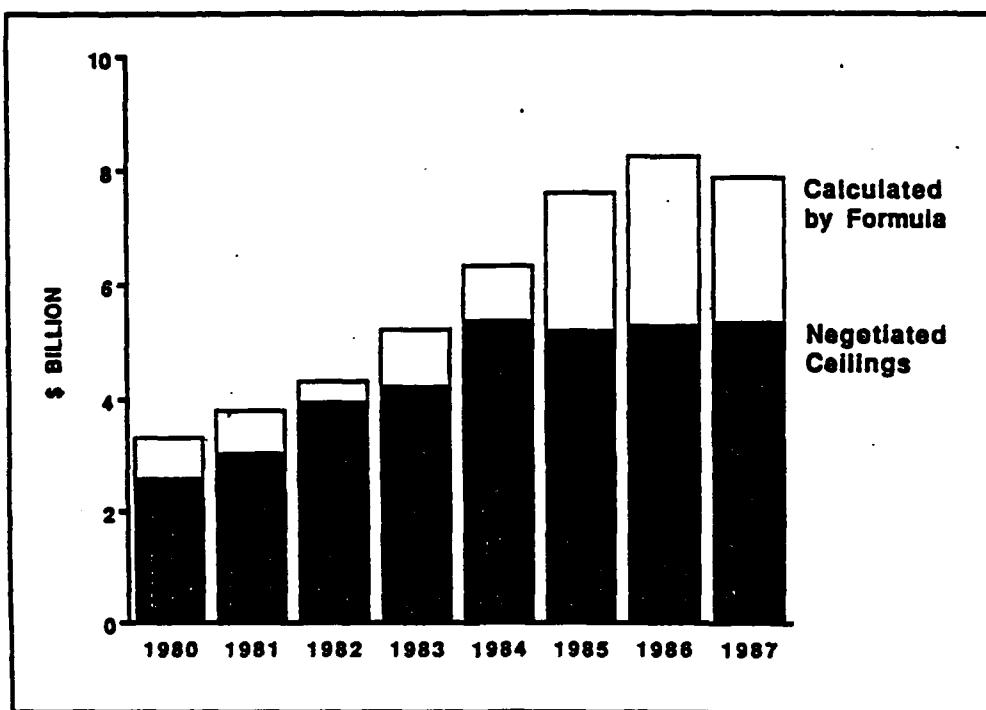


Figure IV-1. IR&D/B&P CEILINGS

Small business also has the opportunity to participate in DoD contract-funded R&D under the Small Business Innovation Research (SBIR) Program. Mandated by Public Law, PL 97-219, passed in 1982, the SBIR Program calls for the DoD to set aside a portion of its R&D program for small business. Awards are made on a competitive basis in response to a formal solicitation made by the DoD each year. Only small business firms can compete. Each year, 1.25% of the DoD's extramural R&D budget (contract R&D excluding in-house expenditures) is directed to the SBIR Program.

In FY87, DoD SBIR Program funding totaled \$202M. This represents about 15% of the total \$1.35B 6.1 plus 6.2 technology base categories of funding going to industry in FY87. Thus, through the SBIR Program, there already is in place an activity that fosters and encourages the participation of newcomers to the defense business.

The argument also fails to recognize that many markets are dominated by a few companies. Newcomers face the same challenge entering any of those markets, and most of them enter initially at the subcontractor or supplier level.

The argument implies that small firms are "innovative" while large firms are not. There is no evidence to support this assumption. Large firms have generally grown from small firms, and their success in growing is often attributable to their continuing innovativeness supported by independent research.

The solution frequently offered is to increase competition by replacing IR&D with increased contract R&D. This would do just the opposite - it would decrease competition. The government would decide what lines of research to explore, what ideas to follow, and which companies would be "awarded" these research contracts. Consequently, we would lose the most important form of competition of all - the competition of ideas. The current system of IR&D, with its key feature of independence, allows all companies - large or small - to decide independently which avenues of research to pursue. That assures a rich mix of alternatives which will be available to our defense planners to meet evolving threats.

Those who argue that IR&D is a subsidy to defense industries ignore a critical difference between commercial and defense business. For example, when one buys a new automobile, the price includes all of the costs necessary to design, produce and distribute the automobile as well as a profit for the manufacturer and dealer (assuming that they are profitable). These costs include the manufacturer's independent research and development (IR&D) efforts that developed the technology and processes that made the design and production of the automobile possible. The manufacturer recovers these costs by selling automobiles. If he is unsuccessful at selling automobiles, he will not recover his research and development costs. If that situation persists, he will eventually be unable to continue his IR&D efforts and his business will fail because he will not be able to develop new products. In commercial sales, a company's entire IR&D expenses are included in the price of its products. Defense contractors, on the other hand, recover only about 40% of their IR&D costs. In truth, IR&D should be regarded as a subsidy of the Government by industry.

Some of the arguments for reducing the IR&D and B&P ceiling are based on a "fairness" concept that IR&D should bear its "fair share" of budget reduction. A contrary conclusion seems more logical. At a time when procurement budgets are being reduced, our adversary's numerical superiority will almost certainly increase. That makes the continued achievement of technological superiority even more important. Total IR&D is quite small in relationship to procurement. Therefore, a major cut in IR&D, with the funding applied to procurement, will have only a small effect on Soviet numerical superiority, at the cost to the United States of forgoing research which is the most likely source of the technological advances our forces need to offset that already existing numerical superiority. Through its own considerable investments in technology and successful espionage, our adversary has narrowed our technological advantage. Thus, it could be argued that when procurement budgets are declining, we, as a country, should increase our investment in IR&D.

In an issue paper prepared as part of the FY90-94 Program Objective Memorandum (POM) review by the Defense Resources Board (DRB), the Assistant Secretary of Defense for Program Analysis and Evaluation reportedly has suggested a number of options for the management of IR&D, including reduced cost recovery by defense contractors for IR&D expenditures. Reportedly, a cut in IR&D of over \$1B is being discussed. If this level of reduction in IR&D is approved by the DRB and implemented by the DoD, the rate of technological advancement will be slowed and there will be further substantial erosion in the capability for the defense technology base to provide technologically superior systems to the Armed Forces.

It has been argued that industry will continue to invest in IR&D at current levels, even if ceilings are cut substantially, with industry making up the difference out of profits. That is simply not the case, because industry cannot afford the additional investment in long-term growth when short-term competitive pressures demand continually expanding investment in bid and proposal costs. The array of acquisition "reforms" imposed by Congress and DoD on industry during the past 5 years has already created a significant "squeeze" on contractor profits.

In a study released in February 1988, the Harvard-based MAC Group measured the combined effects of a number of changes in defense acquisition policy and tax law on past contracts including:

- o Cost sharing
- o Profit policy changes
- o Changes in progress payment rates

- o Required contractor funding of special tooling and test equipment purchases
- o Lower cost recovery, including IR&D/B&P
- o Tax law changes including lower rates and reduced deferrals

In that study the MAC Group determined that the combined effect of these and other changes will be a significant reduction in industry IR&D investment and pursuit of lower risk (and thus lower technology) solutions to DoD's needs.

In a similar study completed in July 1988, the Logistics Management Institute (LMI) modeled the combined effect of three of these policy changes: revised profit policy; reduced progress payments; and deferred recovery of special tooling and test equipment costs. Using what it characterized as an "equivalent concept" to that used by the MAC Group for measuring the financial effects of these changes, LMI concluded that they would result in:

- o Lower return on sales
- o Much greater contractor investment working capital
- o A substantial reduction in return on investment -- from 22.9% to 13.1% return (IRR).

In essence, LMI's conclusions endorse those of the MAC Group. These conclusions lead inescapably to the MAC Group's determination that companies will, in the face of these policies, have to substantially reduce their investments in IR&D.

Thus, it seems quite certain that lower ceilings and other policies will lead to lower contractor IR&D spending and will negatively affect our ability to develop and apply technological solutions to future needs. Furthermore, it seems likely that most of the reduction in spending will come from IR&D, since contractors are motivated to continue B&P spending levels in order to maintain their base of business. Clearly, this would exacerbate the situation.

The long-term effects of reduced IR&D spending may go beyond even the decline in technology flow. The defense industry, like others, competes in the market for scientific and engineering expertise. Scientists and engineers are attracted by exciting and challenging but also stable work. Cutbacks in IR&D will result in a migration of scientists and engineers from defense to other industries.

In conclusion, IR&D has suffered because of the increased expenditures for B&P activity in recent years. At the same time, an adequately funded B&P program is essential to satisfy DoD's desire for increased competition. As a result, IR&D investment must be maintained to complement the defense technology base, the foundation of our technological superiority strategy.

Industry is unable to meet these expanding IR&D/B&P needs because recent acquisition policies are reducing profits available for discretionary investments. Running counter to these upward pressures on IR&D/B&P investment is the desire by some in the Services and OSD to reduce IR&D/B&P costs to increase available budgetary funds for procurement. Thus, OSD has both the responsibility and the opportunity to take the long view and sustain IR&D at the level necessary to assure an adequate investment in the Defense Technology Base in order to support our country's military needs in light of evolving threats.

#### THE IR&D COST RECOVERY PROCESS

One aspect of IR&D has been a subject of debate in government and industry for some 40 years: how industry should recover the costs of IR&D and B&P, and what percentage of these costs should be recoverable, given that the customer is the U.S. Government.

In the commercial market, the prices of a company's products or services are determined by supply and demand in the marketplace. The actual cost of producing such products and services may have little or nothing to do with setting prices. The relationship of cost and price sets the only limit on the recovery of commercial IR&D investments.

Although DoD buys many commercial items, most of its purchases, on a dollar basis, are for non-commercial items. The contracts for these items are negotiated, and their selling prices are determined by DoD acquisition policies rather than being set by market factors. These policies generally provide for a price that is composed of "allowable" costs plus markup (profit). Both costs and markup are subject to stringent regulatory limitations.

The formal cost recovery process for IR&D/B&P is defined by Public Law 91-441, enacted in 1970. The law identifies a class of corporations to which the provisions of the law apply (i.e., corporations whose annual cost recovery of IR&D and B&P is in excess of \$4.4 million). An advance agreement with those firms as to the maximum allowable expense for IR&D/B&P is required to be negotiated annually by DoD procurement officials. This agreement establishes the maximum level of IR&D/B&P costs (the ceiling) that can be recovered by corporations in the ensuing year. Recovery is achieved through the inclusion of allowable IR&D costs in general and administrative (G&A) expenses that

become a portion of the cost of contracts between the corporation and its customers. It is important to note that IR&D/B&P is the only component of contractor overhead costs that has this sort of ceiling applied to it for cost recovery purposes. All other overhead costs are totally recoverable if they meet the basic criteria of reasonableness.

Historically, only about 75% of the total IR&D and B&P costs incurred by contractors have been allowed as G&A costs (see Figure IV-2). In 1987, total incurred costs were \$7.3B, of which only \$5.3B were allowable. The remaining 25% or \$2.0B was excluded from the selling price. This \$2 billion constitutes a reduction of contractor profits.

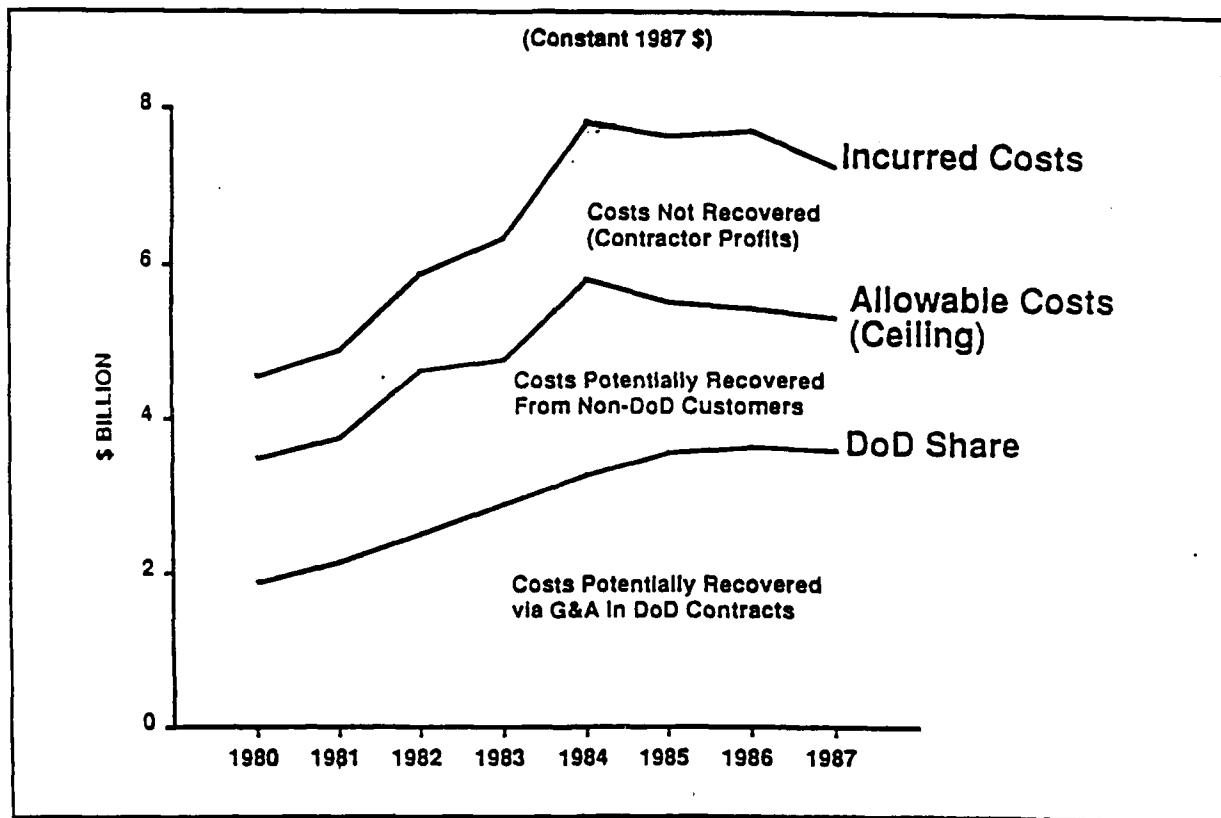


Figure IV-2. IR&D/B&P Costs

The imposition of ceilings on recovery of IR&D and B&P costs is not the only way that contractor-incurred IR&D costs are reduced for the DoD. DoD's requirement that IR&D and B&P costs be allocated to all of a business segment's products or services produces additional cost reduction for the DoD. This occurs

because any products or services sold to non-DoD customers must bear a part of the IR&D and B&P. This is true regardless of whether the IR&D or B&P is relevant to any non-DoD products or services.

This process reduces the DoD share of the IR&D/B&P costs to about 40 to 50% of the company's incurred costs (see Figure IV-3). In 1987, the DoD share was \$3.6B of the \$7.3B incurred. In effect, a company's non-DoD customers pay for about half of the IR&D and B&P effort performed for the benefit of DoD.

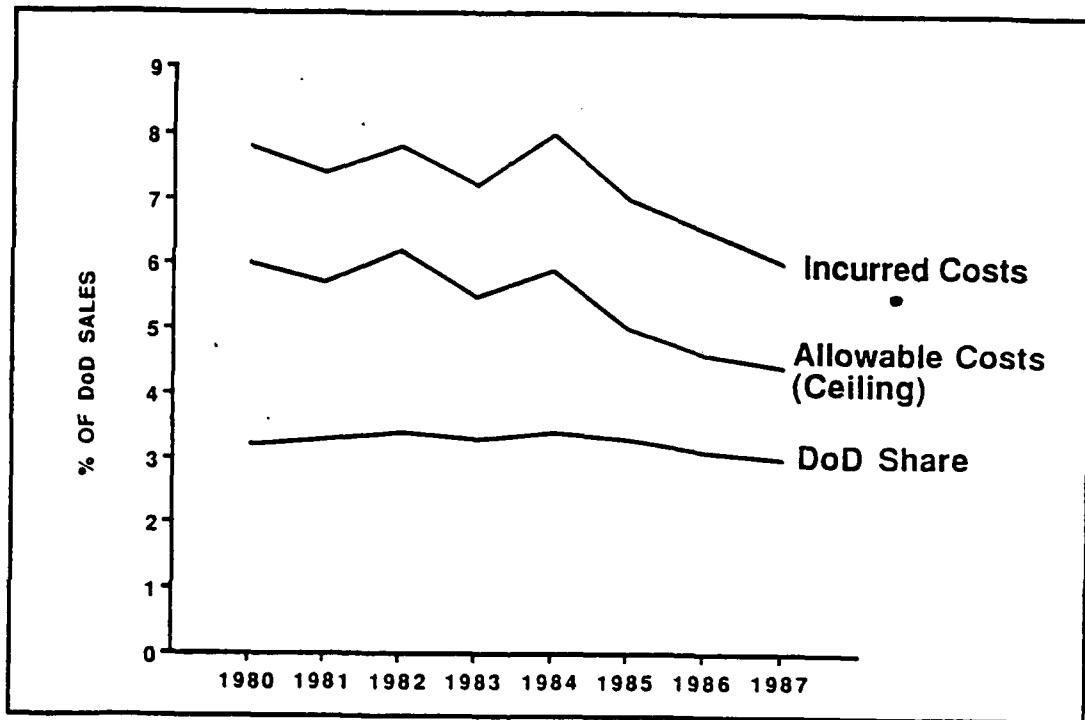


Figure IV-3. IR&D/B&P COSTS

Furthermore, the company has no guarantee that it will recover even the negotiated ceiling amount of IR&D expense. There is further risk of G&A not being recovered if the level of new business (contracts) obtained during the year is less than expected or if competition forces prices down to where they do not cover all costs. Either case (costs excluded from the selling price or costs not recovered because of adverse business conditions) will produce a one dollar reduction in earnings or a one dollar loss for each dollar of such costs that are not recovered.

The concept of G&A recovery through sales is not widely understood. The inclusion of IR&D and B&P as an element of cost in the pricing of defense contracts is a requirement of DoD's contract pricing policy. Under a negotiated DoD contract, it is the only way to recover IR&D and B&P costs.

Yet, cost recovery through sales of products to the government is commonly thought of by government personnel as a sale of the IR&D effort. This perception is incorrect. Industry is not in business to sell G&A nor is it in business to sell IR&D. Companies are in business to sell products and services and earn a fair profit. Only by selling products at a profit can industry recover any portion of its IR&D costs.

Over the years, there has been a series of proposals on other ways to structure cost recovery of IR&D/B&P. For example, there are those in DoD and Congress who ask the question: if IR&D is so essential to defense contractors, wouldn't they continue to fund it even if the costs were not recoverable on DoD contracts? The answer is that perhaps the defense industry would continue to fund IR&D - but only at a severely reduced level. At such a reduced level of funding, the longer term, higher technical risk projects would certainly be dropped in favor of more near-term risk reduction IR&D. At severely reduced levels, it is conceivable that B&P efforts would consume the majority, if not all, of the contractor's discretionary funds.

There have been several other proposals within Congress and the DoD to fund IR&D as a contract line item or as a grant. Critics of IR&D argue that in this manner the Government would be able to direct contractor research along the lines that it prefers. Unfortunately, a contract approach would destroy the basis for IR&D's benefit to the DoD. IR&D, by definition, is independent of contractual constraints, thereby giving the DoD a wide array of technological options not available through direct contracting. Although a grant might not require a contractual statement of work, procedures for the allocation of grants to industry could, over a period of time, lead to similar constraints.

In 1983, Congress imposed a specific limitation, a cap, on the aggregate IR&D/B&P ceilings DoD can allow its contractors to allocate to contracts. The leveling off of IR&D/B&P investments in recent years is probably due in part to this cap. In addition, each of the Services has exerted downward pressure on IR&D ceilings in order to save budget dollars during a period of declining appropriations.

The FY89 Defense Appropriations Bill, for the first time since 1983, does not call for an IR&D/B&P ceiling cap. It is important to note, however, that positive control of individual corporate

and industry-wide expensing of IR&D/B&P will still be maintained by the negotiation of advance agreements with industry.

In 1986, Congress directed the DoD to commission an objective study of IR&D/B&P. DoD selected RAND Corporation to conduct the study. The study, which included an econometric analysis and in-depth interviews with industry and DoD, concluded earlier this year. It has been briefed to DoD, Congress and industry, and a final written report is due momentarily. The econometric study demonstrated that the current cost recovery process acts to stimulate additional investment by the defense contractors:

Contractors as a whole increase their spending on IR&D proportionately more than their cost recovery. If, for example, a contractor's cost recovery increases by one dollar, the contractor's total annual spending on IR&D will increase by over two dollars. In effect, the contractor spends the entire additional dollar recovered from DoD and spends an additional dollar from its own sources . . . Some critics have claimed that IR&D cost recovery is a subsidy to contractors - that firms use funds recovered from DoD to supplant corporate funds that would have been spent on R&D. We found, to the contrary, that a dollar of increased IR&D cost recovery stimulates two dollars of IR&D effort. Increases in cost recovery stimulate contractors to increase their own efforts.

In conclusion, it appears that the current system of partial cost recovery through overhead (G&A) is working reasonably well, and certainly better than any of the alternatives that have been advanced.

#### DoD MANAGEMENT OF IR&D

The formal management process for IR&D, as we know it today, began in 1970 with the enactment of Public Law 91-441. The law, the provisions of which were described earlier, was passed because, in the judgment of Congress, there was a need for increased control of the IR&D expense incurred by industry.

OSD has established two informal groups to assure adequate control over IR&D expenditures. The Tri-Service Negotiations Group (TSNG) and the Technical Evaluation Group (TEG) are the organizations responsible for negotiating and evaluating the ceilings on allowable IR&D and B&P for large defense contractors. Each group consists of one member from each service. Consequently, the individual members must contend with potentially competing objectives of OSD and their individual service.

The technical evaluators for each service component perform the following major functions: conduct technical evaluations of contractor IR&D activities, develop the DoD investment strategy to help guide contractor efforts, monitor the technical requirements of their own service component, and advise the negotiators as to the technical quality and potential military relevancy of the IR&D to DoD.

The negotiators, in addition to reaching advance agreements on allowable IR&D and B&P expense levels with the corporations, perform other important functions. They evaluate and approve the accounting process by which contractors determine and distribute their IR&D costs, and they develop (and control) the total ceiling levels for the services and OSD to provide to Congress.

#### The Negotiation Process

The DoD Inspector General has recently studied the IR&D management process and concluded that the IR&D program was productive and, in general, well managed. The IG concluded that there were broad differences in the way that the service components were negotiating with the corporations for which they were responsible and that the inconsistencies in negotiating technique could result in inequities. To improve this situation, the IG recommended that a uniform negotiating policy be developed to govern the TSNG activities and that a formulametric system be devised to determine the specific amount of allowable expenses.

OUSD(A) has proposed a set of policies and formulae to be used to introduce greater uniformity into the negotiation of advance agreements. The formulae have been devised with the specific intent of introducing a systematic procedure into the process without sacrificing the flexibility available to the negotiators.

On the other hand, the members of the TSNG believe, quite naturally, that they are providing uniform judgments now, and no major tinkering is needed. There are indications of some lack of uniformity in the negotiation of ceilings, and this should be addressed.

There are two possible approaches to achieving uniformity--centralization of negotiations under OUSD(A) or increased oversight and control over the service negotiations by OUSD(A). Industry favors centralized policy management. They believe there would be more consistent and equitable treatment as a result. Uniformity in the establishment of ceiling amounts for forward pricing purposes is of particular concern to industry.

OSD also sees some merit in centralized management, but not within OUSDA(A). This office is viewed as a staff function which should not be charged with an operational responsibility. OUSDA(A) reportedly made an informal offer to consolidate the

activity under the Air Force -- which now has over half of the negotiation workload -- and the offer was declined. According to OUSDA(A), the Service Acquisition Executives oppose centralization.

#### IR&D Technical Evaluation Process

DoD has established an elaborate and extensive system of technical evaluation of contractor IR&D projects. Technical Plans describing IR&D project plans and accomplishments are prepared by each contractor business segment and distributed throughout the DoD laboratory community for technical evaluation. Approximately 10,000 projects are reported on annually. Technical scores are given to each project by evaluators within the DoD Laboratories (approximately five evaluations per project on the average) and these scores are combined into a single technical score for the company. This score directly impacts the negotiated cost recovery ceiling. In addition, to "validate" the scores, the DoD holds an On-Site Review of each contractor's IR&D program every 3 years during which a team of DoD technical evaluators reviews the IR&D projects firsthand. Obviously, this is a costly process.

The RAND study, OSD and industry all support a simplified and less costly approach to the annual technical evaluation process. The cost and effort that go into the development of Technical Plans and hosting on-site evaluations seem considerably out of proportion to the benefits achieved. Industry estimates that 3 to 5% of total IR&D expenditure (\$150M to \$200M) is spent on this technical evaluation process. Although this is not a precise estimate, it is clear that the current excessive technical evaluation process detracts from the resources better spent on research and development activity toward a healthy defense technology base.

Some measure of support exists for doing away with the evaluation process entirely. The negotiators, however, consider the technical evaluation to be invaluable and unanimously claim that their function could not be accomplished without technical input, particularly when trends are toward large change.

Current OSD initiatives to introduce greater uniformity into the negotiation procedures include the proposal to increase the impact of technical score in the development and negotiation of the ceiling. The Task Force believes this would be a mistake. Technical scores are at best subjective. Historically, there has been little uniformity in project scores from year to year, even when the content of the project has not changed significantly. In addition, heavy emphasis on technical scores in the negotiations seems to conflict with the desire to reduce administrative costs in the technical evaluation process. If technical scores had a greater impact on contractor ceilings, contractors would spend considerably more than they do now preparing IR&D project

reports for DoD technical evaluation and would thus spend less on doing the research itself.

One idea proposed to reduce technical evaluation costs is to eliminate the Technical Plan entirely and use the On-Site Reviews as the IR&D project scoring mechanism. We believe that the Technical Plan does serve a useful function. The Technical Plans are used by many contractors to partially satisfy their own internal planning and control requirements. In addition, the Plans provide a means of communication between the scientists and engineers in the defense industry and their peers in the DoD laboratories. The evaluation process can be simplified without eliminating the Technical Plans and thus the advantages they provide.

Most parties agree that simplification of the current technical review process is a worthwhile endeavor. Moving to a 2-year review cycle is already under active consideration by OUSD(A). Other options include shorter, simplified Technical Plan write-ups and simplified DoD evaluation criteria. In addition, the people conducting the evaluations, that is, the engineers and scientists in the DoD Laboratories, should be asked for their ideas on how the process might be simplified and how, at the same time, the benefits of industry-DoD technology transfer might be enhanced.

#### RECOMMENDATIONS

1. The decision as to the aggregate level of IR&D/B&P ceilings, since it is the principal determinant of contractor IR&D spending levels, is one of DoD's most important decisions, because it can have a significant impact on the country's long-term ability to defeat the threat. Therefore, the ceiling should not be inflexibly linked to any other parameter such as TOA or the defense procurement budget. The decision should be consciously made by the Secretary of Defense, because he has the responsibility for the long-term defensive capability of the country.
2. Reject any proposal to substitute a system of grants or contracts for the IR&D system and retain the current method of IR&D/B&P cost recovery through overhead (G&A) on contracts.
3. OUSD(A) should increase its oversight of the process of negotiation of individual company IR&D/B&P ceilings in order to assure uniformity and equity and should direct the simplification of the overly complex technical evaluation process.

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## V.

# Capital Formation and Management

### CAPITAL FORMATION

The financial performance of the national industrial and technological base is directly linked to its ability to accomplish its tasks which are essential to the security of the United States. After several years of increased DoD appropriations, followed by a leveling off and decline, the industry is viewed with skepticism by most investors. Price/earnings (P/E) ratios in many sectors are the lowest in at least 25 years.

In recent years the industry has obtained its capital needs primarily from internal cash flow, i.e., earnings from operations generally tax-free because of carry-forward credits and from depreciation and other tax benefits no longer available. Because of narrowing profit margins on more competitive contracts brought on by DoD reactions to budgetary constraints, tax law changes, and expiration of previous carry-forward losses, it is doubtful that internal cash flow will be sufficient to meet future capital needs.

Access to the capital markets is now available only to the largest companies and largely restricted to debt securities. Second tier companies have little, if any, access. Overcapacity exists in the industry. Will the nation continue to support this overcapacity? If not, reorganizations and bankruptcies may proliferate, particularly in the second tier. In reorganizations, a company can continue to operate to complete DoD contractual obligations, forcing equity holders to bear the brunt and providing a further disincentive to invest.

In order to gain investor favor, industry and government need to make adjustments. In many cases, industry should undertake to improve productivity which lags national averages. Management investment in company equity (i.e., personal stock ownership by Senior Management) is often seen as a measure of dedication to the firm. Because defense industry management personal investments are below the average, additional investment could improve investors' view of the industry. Industry should move strongly to increase management investment in company equity. In terms of defense policies, there are a number of acquisition issues that would improve stability and predictability of financial results and thus the capital-raising capabilities of the industry. Two in particular stand out:

- 1) Multi-year contracting has been recommended many times, and should not be abandoned as a goal.
- 2) A better relation between risk and rewards, including a greater share of cost reductions, would increase the incentive to invest.

A number of other changes would also be useful, including increased progress payments, raising caps on profit levels, and increased DoD financing of tools and equipment. In order to better balance risk and reward for both contractors and those who might invest in them, DoD should consider reducing risk through more Government Financed Equipment, increasing the reward factor through bigger profit participation, and/or greater incentive payments for reaching productive goals. In addition, it is clear that many features of the 1986 Tax Reform Act have had difficult consequences for the defense industry, particularly the ITC and R&D credits, and completed contract method.

Unfortunately, almost any changes in defense or fiscal policies will involve either increasing outlays or raising revenues. The first is probably in violation of Gramm-Rudman-Hollings ceilings, and the second is politically impossible at present. This suggests that the office of the Secretary of Defense needs to seek a more active role in economic policy making, which will undergo major changes in the next 10 years.

What else can be done to arrest a declining financial situation? The most pressing need is for a comprehensive objective evaluation of the U.S. defense industry from both the financial investment point of view and within the context of our economy as a whole. Drawn from finance, academia, industry, and government, this group should examine not just restrictive cash flow problems but also:

- 1) The fundamental obstacles to investment in defense.
- 2) Whether action should be taken at all in some areas, or market forces should be allowed to take their course?
- 3) The best ways to model various aspects of our defense business -- widespread competition may be less productive in some areas from a more national approach. In view of the regulation by Congress and DoD as to contractual terms, length of contract, development, production, etc., should some parts of industry be considered a National public utility? If so, how should they be regulated?
- 4) The most advisable tax policies for encouraging investment in defense.

- 5) How risk-reward balances can be improved.
- 6) Proper balances between directed and independent R&D in defense needs and for the economy as a whole.
- 7) Effect of short-term market biases.
- 8) Acquisition issues which are disincentives to investors.
- 9) Relation of progress payments to interest rates.
- 10) How defense incentives should be viewed in relation to larger economic issues of U.S. trade and competitiveness.

This kind of study is important for several reasons. While some ad hoc testimony has been gathered from financial analysts and industry experience, there is no consistent, independent study of "defense" in its varied sectors from the financial point of view. For example, neither Treasury nor Commerce keep defense numbers because the industry is so hard to define. There is no database.

What are the factors -- economic, fiscal, regulatory, political, psychological, and managerial -- that are reflected in a defense stock price? It is one thing to observe that the P/Es of some sectors are low, and another to assert that specific policy changes will raise them. Some leading edge sectors may naturally have higher P/Es than others.

These and other concerns involve a much larger effort than a subgroup of the DSB found it possible to undertake.

Therefore, in order to better understand all of the forces reflected in the marketplace for "defense" securities and to make plausible assertions about the correlation between defense policies and access to capital, we recommend that the SECDEF create a special study group, as outlined above, to report by December 1, 1988.

#### **CONSULTANTS' PARTICIPATION IN THE ACQUISITION PROCESS**

Our committee's review of the issue of the use of consultants in the defense acquisition process began with a study of the Packard Commission's recommendations in this area.

The details of the current investigation into the possibly illegal activities of consultants are unknown at this time, and therefore cannot be addressed specifically in this report.

The Packard Commission's primary thrust was in the area of self-governance. We agree with this approach.

We recommend that the self-governance initiatives be expanded to include a broader range of requirements and expansion of involvement to include consultants.

The limitations of time for this review and the novelty of experience of the participants requires additional study by a group more knowledgeable about the role of consultants in the acquisition process.

Nonetheless, our committee recommends actions in the following areas:

- o develop a code of ethics for consultants similar to the one prepared by the Ethics Resources Center, Inc. (ERC), for the defense industry.
- o Expand the ERC code of ethics to all defense contractors and their subcontractors.
- o Require consultants to fully disclose their client lists to new clients.
- o Require contractors to disclose the identities of their consultants to the Department of Defense.
- o Have senior officers of defense contractors approve all consultant contracts.
- o Increase resources available to the Department of Justice to prosecute defense acquisition frauds.
- o Permanently revoke the security clearance of anyone convicted of a felony in the Defense Acquisition Process.
- o Have corporate defense contractors establish ethics committees composed of outside directors on their board of directors. The committees would provide oversight and focus attention on the overall ethical behavior of the corporation, including the use of consultants.
- o These suggestions should be voluntarily adopted by the industry to expand their self-governance policies.
- o The Department of Defense may require compliance at a later date, if necessary.

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## VI.

## Incentives and Competition

### EXECUTIVE SUMMARY

The Subgroup on Incentives and Competition has proceeded from the simple premise that defense industrial managers operating within our free capitalistic society will make the most appropriate investment choices if their business interests and the government's objectives can be brought into alignment. This is a win-win concept, in contrast with the zero sum game adversarial relationship that too often characterizes defense procurement and which tends to place primary dependence upon detailed government oversight and audit rather than the self-interest of government and industry teams working toward well defined common goals.

- Our approach to this effort has been to seek a realistic appreciation of what our national security requires of its defense industrial base; to understand the effects, both positive and negative, of existing statutes, regulations, policies and programs on the behavior of that industry in its own self-interest; and to make recommendations for constructive change.

The subgroup report includes a survey of recent study findings that provide evidence of substantial disincentives to industry investment necessary to create and maintain a defense industrial and technology base that is modernized, competitive and responsive to national security needs. The implementation of contracting and competition policies by the procurement agencies received special attention as major elements of the incentive environment influencing contractor investment decisions. Our subgroup has therefore examined this subject in some depth from the disparate viewpoints of the service competition advocates, the project managers and industry.

- There are a number of industrial and technology base initiatives that have been taken by the services and by industry which are aimed at achieving specific objectives. Some of these have been notably successful, some less so, and for others it is too soon to pass judgement. Our subgroup has attempted to provide some insight on appropriate criteria for government participation or leadership in such pump-priming initiatives.

Finally, our subgroup has examined some of the new Secretary of Defense and USD(A) policies and management initiatives which relate to the subject of incentives and competition and has offered specific suggestions for constructive change.

Findings:

- 1) Up front investment to strengthen the defense industrial base will be increasingly difficult in an environment of flat or declining defense budgets and increasing government pressure on industry cash flow and profit. With service leadership giving priority to protecting readiness, it will be doubly difficult to fund investments with non-program specific or long-term payoff.
- 2) There is a notable lack of uniformity among the services in procurement and in implementing guidance or policies that influence capital investment decisions by industry.
- 3) The full benefits of multi-year procurement have never been achieved. The present annual funding constraints lead to limited cost savings and discourage contractor investment. The statutory approval by Congress of contingent liability to cover multi year long lead economic purchases will optimize savings and encourage contractor investment.
- 4) Failure to provide for indemnification protection in the event of program termination strongly discourages contractor investment in facilities that would have long term benefit to the program.
- 5) Realistic quantitative objectives for increasing the amount of competition in defense contracting have probably been achieved. Actual competition substantially exceeds that claimed if credit were taken for competition at subtier levels or in follow-on procurements from sources originally selected by competition. The total costs, direct and indirect, of competition are not documented to balance against claimed benefits. Competition policy could appropriately shift primary emphasis from quantitative to qualitative improvements e.g., reliability).
- 6) The proposal for creation of production base advocacy is seen as a move toward constructive change. If the proposed function is consolidated into that of the DUSD(A), it could facilitate his providing effective management as the central authority within the DoD for developing industrial base policy initiatives and coordinating service implementation directives. This should include consideration of the special problems of the subtier suppliers such as data rights, cash flow and risk sharing with the primes.

- 7) The recently approved change to the Best and Final Offer (BAFO) processes is a step in the right direction. We believe that there should be additional improvements in technique that would further constrain the use of even the first BAFO to those cases that are absolutely necessary, as well as eliminating further BAFOs. For example, the government could use a two-step process for negotiated procurements. The first submission by each offeror would be the entire proposal, but excluding price/cost data. After technical discussions are complete, the cost proposals would be submitted by all offerors who are technically responsive.

Recommendations:

The USD(A) should:

- 1) Develop and implement centralized and integrated procurement policies to effect industrial base development, acquisition processes, and coordinated service implementation.
- 2) Initiate programs to create adequate incentives for long-term industry investment in technology, production processes, and modernized facilities.
- 3) Review the competition acquisition process to ensure that procurement policies and the competition advocates give sufficient emphasis to a healthy competitive business environment, as well as one based on good business sense and total product quality.
- 4) Consolidate the functions of production base advocacy, including the special concerns of subtier contractors, with those of overseeing defense industrial base programs.
- 5) Convene a joint government-industry group to consider further modification of regulations governing Best and Final Offers (BAFOs).

**SURVEY OF RECENT STUDIES**

Through a variety of contract terms, the Government seeks to create incentives for its contractors to invest in technology, productivity, and personnel. It also encourages them to undertake tasks which can only be performed at high technical risk.

Since 1985, Congress, DoD, and industry have each attempted to determine whether these incentives are accomplishing their goals. None of the various studies and legislative initiatives have resolved the conflicting perceptions which their authors have of these incentives. Nevertheless, the studies at least provide valuable insight into the utility of the contract incentives.

We have examined the Defense Department's "Defense Finance and Investment Review" (DFAIR) of 1985, and the reports of the Ad Hoc Industry Advisory Committee to the Senate Armed Services Committee (IAC), the Harvard-based "MAC Group," both of 1988, and the "Financial Impact of Recent Contract Pricing Changes" report prepared for DoD by the Logistics Management Institute (July 1988). Each provides significant conclusions on the value and effectiveness of contract incentives.

Both the DFAIR and MAC Group reports deal principally with contract profitability. In DFAIR, DoD surveyed approximately 100 major companies to measure the profitability of their defense business. DFAIR sought to determine whether contractors' profits compared with those of commercial industry and the effect of those profits on investments benefitting DoD.

DFAIR concluded that changes to DoD's profit policies during the early 1980s resulted in defense profits roughly equalling those in the commercial sector.

Further, and more importantly, DFAIR found that the profit policies accomplished their principal goal: contractor capital investment in facilities, plant, and equipment had increased.

Subsequent to the publications of DFAIR, the report was criticized severely by GAO and others who doubted the method used in its analysis and challenged the data chosen for its analysis. These challenges came at the same time that Congress faced the need for outlay reductions under the Gramm-Rudman-Hollings Emergency Budget Control Act. In that environment, Congress legislated changes to DoD's profit, progress payment, and special tooling and test equipment financing policies. In 1986, it mandated changes which: 1) reduced profit by 1% overall and sought to encourage investments in productivity and risk taking; 2) reduced progress payments by 5%, and 3) mandated contractor financing of special tooling and test equipment purchases.

At the same time, and without assessing the effects of the foregoing changes, Congress also greatly reduced the tax deferrals available to defense contractors by decreasing the amount of income which could be reported under the completed contract method of tax accounting (CCM).

In this same period, DoD revised other contract financing policies. The practices of cost sharing (whereby contractors pay a portion of the contract price as an investment in possible future business) and fixed-price contracting for development work significantly increased contract risk.

The IAC report, written at the request of Senators Jeff Bingaman (D-NM) and Phil Gramm (R-TX) surveyed over a dozen acquisition

policy issues. In several cases, it reported that the Congressionally mandated changes and the changed DoD policies reduced or eliminated the positive effects of the policies measured by DFAIR.

The IAC report found a conflict inherent in a number of the policies created by Congress and DoD. It stated its case simply. Companies have a finite reserve of profits from which they take the funds for capital investment. To the extent that these profits are reduced or capital investments are directed elsewhere, they are not available for investments benefitting DoD. For example, the profit policy is supposed to reward risk taking. However, it fails to reward investments in IR&D which, the report argued, is the highest risk investment companies value.

The IAC report found a further conflict between the profit policy's reward of investment and the requirement for very large investments in production special tooling and test equipment (STTE). The report found a dollar-for-dollar reduction in beneficial investments (such as productivity-enhancing equipment) for each dollar invested in STTE.

Shortly after the IAC report was published, the MAC Group issued its report. Like DFAIR, the MAC report sought to measure contractor profitability. To do so, the MAC Group obtained data on the financial performance of nine major programs which were not subjected to the changed policies of the 1985-86 period. The MAC Group's analysis was comprised of constructing a cash flow model of those programs before the imposition of those changes and then measuring the effect of the changes by modeling their impact on the earlier, successful programs.

The MAC Group chose to model the effects of policies which could be quantified:

- o Cost sharing
- o New profit policy
- o Progress payment reductions
- o Special tooling investments
- o Lower cost recovery (such as lower IR&D recovery and increased unallowable costs)
- o Tax law changes

The MAC Group's principal findings are of great significance:

- 1) For the nine programs analyzed, it found that additional company financing of \$8.5 billion, equivalent to 50% of the companies' total 1985 equity, was required by the changes it measured.
- 2) Profits were reduced by an average of 23% on the nine companies' defense business.

- 3) Return on equity would fall by 30 to 40% under these new policies.
- 4) There would be no financial reason to bid the programs.

Further, and of perhaps the greatest significance, the MAC Group found that companies would probably not be able to raise the additional financing in the debt or equity markets. In essence, it found that the changed policies would close the financing markets to defense contractors pursuing major programs.

The full effect of these changes, according to the MAC Group, would be that companies would be forced to:

- o Reduce company-funded IR&D
- o Reduce investments in productivity enhancements and modernization
- o Reduce risk by using low-technology alternatives
- o Decline to bid high-risk programs

The LMI study, which reviewed and commented on both DFAIR and the MAC Group report, came to virtually identical conclusions. LMI measured the effects of changes in profit policy, progress payment rates and contractor funding of special tooling and test equipment purchases. Using an internal rate of return (IRR) model, LMI found that the changes:

- o Require much greater contractor investment to cover working capital
- o Result in pretax IRR reductions on the order of 40%.

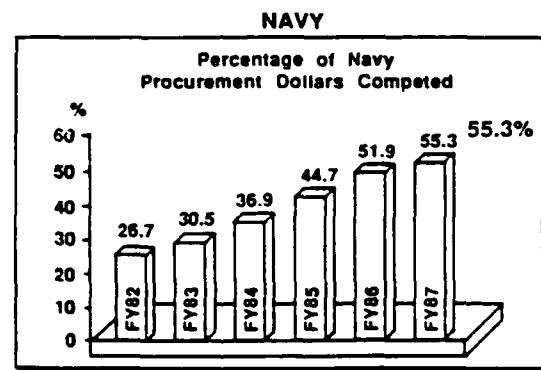
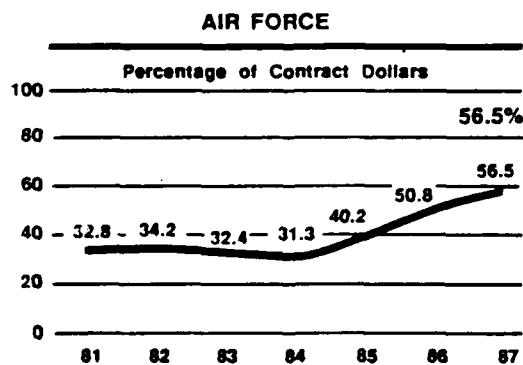
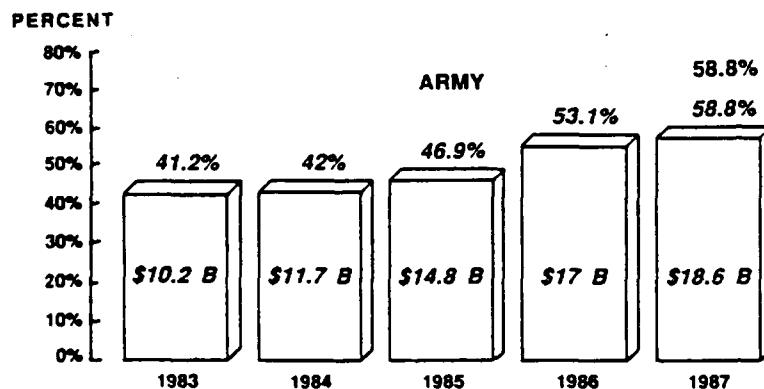
In essence, these conclusions mean that DoD's goals in its incentives would be totally frustrated.

In order for industry to use DoD's incentives to achieve the policies' goals, these conflicts within financing policies must be resolved. Incentives which seek to increase investments in risk, productivity, and modernization must be permitted to work.

DoD's recent initiative to increase progress payments by 5% on contracts awarded after October 1, 1988, is a major step in the right direction. As the MAC Group suggests, further action is essential to measure the impact of changes in procurement policies to assure that incentives work to DoD's benefit in the short and long term.

## COMPETITION AND CONTRACTING

In the acquisition arena, competition has proven to be one of the best contracting tools available to the services. While it had been commonly used by the services prior to 1985, the Competition in Contracting Act (CICA) forced greater emphasis on the use of competition. Competition advocates were created in all three services. All major acquisitions and the vast majority of small acquisitions were rigorously reviewed for competition candidacy. The number of procurement actions and the number of procurement dollars competed quickly became the measure of response to the new competitive thrust. By 1987, all three services approached the 60% point for procurement dollars competed and 90% for the procurement actions competed. (Figures VI-1 and VI-2.) If the "follow on" to competition buys and the sub-contracted dollars competed by prime contractors were added to the totals now reported by the three services, it would equal approximately 90% of all the procurement dollars now competed (Figure VI-3 for Army data.) All of the services believe that they have reached a quantitative plateau beyond which we can expect little more progress.



**Figure VI-1. Competition Scorecards  
Percent of Dollars Awarded Competitively**

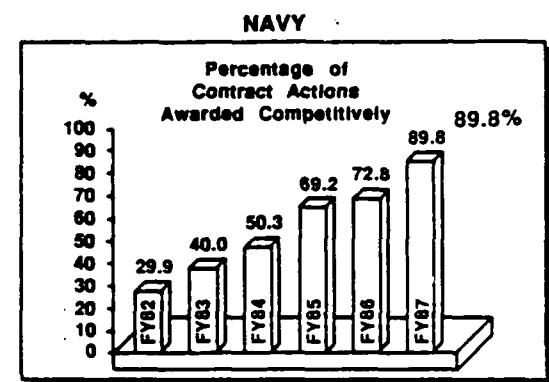
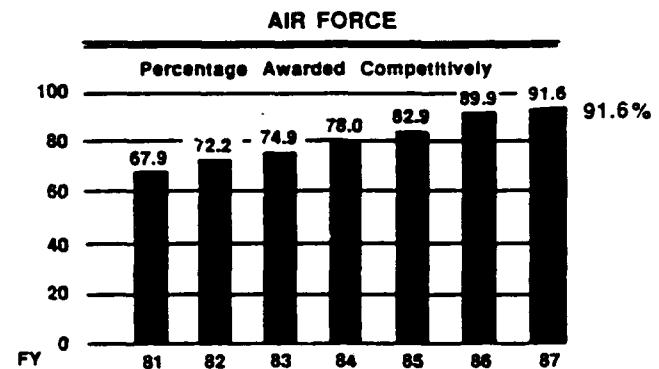
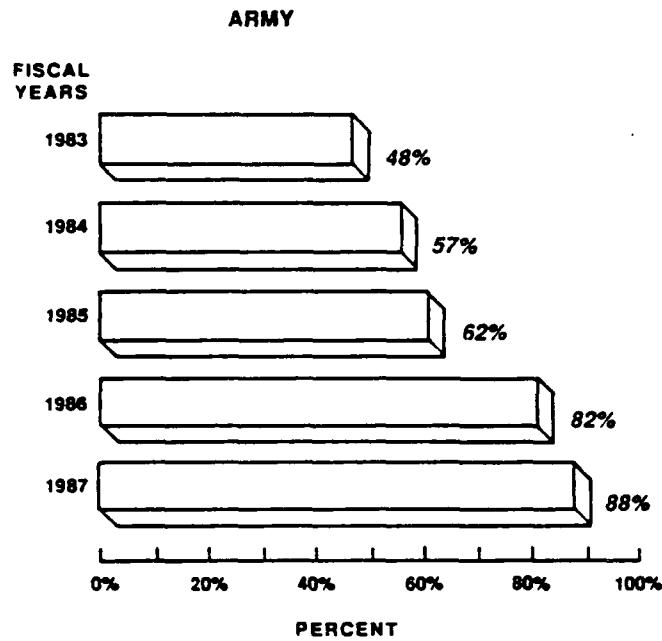


Figure VI-2. Competition Scorecards  
Competitive Procurement Actions



PRIME CONTRACTOR COMPETITION 59%

15%  
SUBCONTRACT  
COMPETITION

15%  
FOLLOW-ON TO  
COMPETITION

Figure VI-3. Army Competition Dollars

To some extent, competition has been pursued "for its own" sake. The introduction of competition advocacy as a dedicated function at field procurement levels has sometimes led to quantitative goals being the measure of merit rather than the overall quality of the competitive strategy. In most cases, the total cost of competition has not been adequately considered, and the "full and open competition" provision of CICA has been extended beyond the intent of the law which was to consider only responsible sources. Another provision of the law requires that justification and approval of all procurements over \$10 million contemplating "less than full and open competition" be accomplished at the Service or Department level. This process in and of itself serves as a powerful deterrent to selecting any acquisition strategy other than competitive for any reason.

In view of the quantitative achievements of the services, it now seems prudent to focus on improving the quality of the competitive procurement process. We should ensure that we are not pursuing competition for its own sake, but that each competitive procurement, major or minor, is clearly justified on its own merits. Poor competitions can result when the strategy is not well thought out or faulty assumptions and analyses are made. Dual-sourcing strategies should only be used when the quantities warrant two sources. If they do not, judicious dual sourcing at the subcontractor level may be a better strategy. "Break out" competition is a very critical strategy and great care must be taken to examine the requirements to properly qualify the new vendor or subcontractor so that overall quality and reliability of the end product is not compromised and any warranty thereon is not jeopardized.

All three services have told us that competition has forced more discipline into the acquisition process. With competition, requirements must be more precisely defined and contractual statements of work must be sharpened. The pressure of competition has also forced contractors to become more responsive and efficient. While this pressure can be healthy for both government and industry, we must not forget that the defense marketplace does not mirror our commercial sector. It is a monopsony and always will be. This reality begs for wisdom in the application of free market principles because they do not universally apply. The defense industrial base should be as competitive and efficient as possible, but it also must fulfill the higher order demands for national security. Some elements of that base have only one customer. They must be treated with equanimity if we want them to survive.

Competition has not only reduced costs but has clearly achieved better performance, higher reliability and maintainability, and better quality, any one of which may be a greater benefit from competition than the instant unit cost reduction. Not only are the services achieving better warranties, they are convinced they

are getting all of this at lower acquisition costs and lower life cycle costs. Contractors are clearly introducing innovative technical and manufacturing approaches which will improve R&M, warranties, and performance and, in most cases, will strengthen the industrial base. As noted earlier, however, the full costs of competitions are not always appreciated or taken into account in the development of acquisition plans. As the DoD Inspector General said in his report on the Audit of Dual-Source Procurement Techniques (Report No. 88-113, June 7, 1988):

Dual-source procurement techniques are providing increased competition. Dual sourcing is a viable technique for moving away from sole-source procurements through the life of a program. However, technical guidance, direction, and execution must be improved before we can determine the savings achievable through the use of dual-source procurement techniques. The methods used by the Military Departments to perform cost-benefit analyses of dual-source procurements do not consider all pertinent costs and overstate potential savings to the Government.

This criticism of one-sided emphasis on competition has been made by many of the experienced individuals from both industry and government program management positions. In particular, it was highlighted during the Defense Systems Management College Alumni Association Symposium conducted earlier this year. (See Figure VI-4).

While our examination of incentives has primarily focused on competition and other factors which collectively influence business decisions of defense contractors, it would not be complete without considering application of incentive contracts per se. Contracts incorporating balanced incentives on cost, schedule and performance have been used with notable success in several major defense acquisition programs. A prime example was the Navy's use of a fully structured contract for the development and initial production of the TRIDENT I (C-4) missile system. The final outcome was win-win. All of the Navy's performance objective were met or exceeded, both development and production costs remained within the bounds of contract incentive effectiveness, and the contractor earned an incentive fee. It is evident that such contracts, when structured with care, can be employed to create a "win-win" environment within which the government and industry (as a team) can pursue shared program objectives. There are other cases that can be cited in which contract incentives were ineffective. In one such example, the relatively small incentives on a development contract were completely overwhelmed by the contractor's overriding concern for getting the program into production. This emphasizes the need for a realistic appreciation of overall program objectives and the structuring of contract incentives that accurately reflect them. It also

- o Technology Transfer Issues
  - Configuration management more complex with multiple sources
  - Perceived lack of protection of proprietary data
  - Fear of technical leveling
  - Fear of data transfer to second source
- o Increased costs due to splitting a requirement for two producers and possibly contracting for an uneconomic quantity
- o Increased life cycle costs and lowering of specification requirements
- o Unqualified sources receiving contracts
- o No accounting or tracking for costs to implement competition, i.e., total net costs or savings of competitions
- o Program stretch-outs; associated cost of delays are not quantified
- o Pursuing competition for competitions sake; stressing statistics
- o Increased protests

**Figure VI-4. Program Management Views  
(Perceived Problems and Concerns)**

illustrates the fact that the government's interests in achieving its goals for an inherently multi-year program and the contractor's interests in his return on investment do not fully converge until the term of the contract approaches the span of the program.

#### **PRIMING THE PUMP**

The current acquisition environment between the DoD and its contractors does not encourage investment in leading edge-process technology and capital equipment to optimize manufacturing efficiency and cost. FSD programs tend to concentrate on engineering (design) aspects without imposing and funding an adequate "transition to production" discipline. While product capability

is an essential priority, the unit selling price of the system in production (affordability) is perhaps an equal priority.

Two specific incentive programs of the DoD that have proven their benefit to the department and to the taxpayer are the Manufacturing Technology Program (ManTech) and the Industrial Modernization Incentives Program (IMIP). While these programs have proven their effectiveness in: 1) accelerating the development of advanced manufacturing technology; 2) stimulating entire factory-wide modernization efforts; and 3) increasing contractor investment in productivity enhancing equipment, improvements need to be made in the DoD-wide management and resourcing of these programs.

#### PROBLEM

Even though both programs have been operating under OSD policy which endorses and requires DoD element participation, service support of these programs has been inconsistent. Budgets have been erratic, management resources have been insufficient, and, in at least one case, service participation was prevented by management decision. The result has been to limit the potential of these programs, to create confusion regarding the commitment of the DoD to manufacturing efficiency, and to discourage industry participation.

#### RECOMMENDATION

We believe that OSD must back up its policies supporting manufacturing technology and plant modernization with consistency of direction and the resources to accomplish the stated goals. Further, OSD must assure that the services provide the support necessary to carry out both the spirit and the letter of these policies.

OSD needs to establish a focal point for manufacturing that can oversee both the research and procurement activities, provide strategic assessment of manufacturing deficiencies, currently or potentially, from either a technical or managerial perspective, direct a long-term program to address these deficiencies, be the advocate for adequate resources, and keep the Secretary regularly advised on the strategic posture of the Department's manufacturing base.

We suggest that OSD establish a joint program office for the management of such an effort for the entire Defense Department. This joint program office would utilize the existing management structure and expertise of the services, particularly the Air Force ManTech Office at Wright Patterson Air Force Base, to consolidate and coordinate all service programs.

With regard to manufacturing technology, the focus should be on solving major technical challenges of manufacturing systems over the long term rather than incremental improvements to existing technology. This should not be done to the exclusion of shorter-term efforts but the bulk of resources should be aimed at technical challenges considerably beyond the ability of a single firm to accomplish within the time frame necessary for defense requirements. The strategic technical planning effort for the entire department should be conducted by this joint office, including project selection and resourcing. This office should be responsible for maintaining relations (and support as appropriate) with national manufacturing efforts such as SEMATECH and the National Center for Manufacturing Sciences. Assessment should be made of international advancements in manufacturing technology and science and mechanisms established to enable the department to benefit from foreign developments. It is essential that service involvement be maintained and the joint program office should solicit and fund projects from the services under a streamlined administrative approval process.

With regard to plant modernization, this joint office should be responsible for promoting and directing inter-service coordination to promote modernization of plants producing for more than one service and, where necessary, for more than one program office within a single service. This office should have the authority to allocate both the burden and savings of an IMIP or similar effort where inter- or intra-service barriers exist to the modernization.

Adequate resourcing of both ManTech and IMIP, as well as derivative and related efforts, is critical if the potential savings are to be realized by the Department. These programs have proven their ability to reduce costs. With the prospects of declining DoD resources, the normal reaction is to cut all programs, and non-hardware programs in particular. We believe that there is a special case for these two programs because they save rather than cost money and will better equip the department to meet future resource constraints. We also believe that there should be a funding goal established, considerably above current levels, by the Department for these programs in relation to the objectives they seek. The objectives are to reduce acquisition costs over the long run and therefore the funding level should bear a relationship with the procurement budget of the Department.

It is important that the funding be both adequate and stable. The Department's funding goal should be established and maintained for at least 5 years. At that point the Department should conduct a review of the 5-year experience to evaluate performance and return to the Department, not only in cost savings and avoidance, but also for contribution to quality improvement and to enabling production of items where no prior method existed.

The proposed joint program office and the strategic planning efforts will need to maintain close ties with industry. Industry involvement at the technical level should be strengthened through the existing Manufacturing Technology Advisory Group. Active industry participation should be sought in the technical working groups to avoid unnecessary duplication, to establish consensus on technical needs, and to explore promising technical approaches prior to project selection and funding. The DoD needs to maintain contact with senior management in the manufacturing area which should be done through the Defense Manufacturing Board. The DoD should utilize the DMB to advise on long-term manufacturing strategies and related management and policy issues toward the ultimate goal of minimizing costs and maximizing quality. Linkages should be established between the DMB and MTAG to assure communication between management and technical communities.

The joint program office should also be charged with the larger issue of total cost (i.e., technical approaches to more efficient overhead structures), as well as projecting the required skill base associated with new manufacturing processes, and should involve university interest and expertise in this resolution.

## VII.

## Subtiers

While recent changes in Department of Defense (DoD) acquisition policies and practices have affected all contractors to some extent, it has been suggested that second- and third-tier suppliers have been affected more severely by these changes than have prime contractors. This subgroup, therefore, was focused on whether any adverse consequences of changes in policy are unique to the subtiers. Clearly, any erosion of critical capabilities within the lower tiers could impair the performance of the entire defense industrial base.

A necessary precondition for examining the subtiers is a description of the characteristics which distinguish a second- or third-tier supplier. Unfortunately, there are no accepted or standard definitions used to categorize contractors. Given this situation, a rather broad definition was arrived at for the purpose of this study. Basically, subtier suppliers were viewed as subcontractors as opposed to prime contractors. These subcontractors, perceived as "smaller" in terms of sales and employment, could be either independent or units of a larger organization. This definition was not intended to exclude firms which have become prime contractors solely as a result of spare parts breakouts. In addition to these criteria, the subgroup primarily concerned itself with companies that manufacture a product, or produce a service, to unique government requirements or specifications. This distinction was made to differentiate the firms in question from those which only sold catalog priced or commodity items.

Although the lack of a clear definition presented problems when collecting and interpreting data, potential problems in non-prime contractor industry groupings could be identified. During the 1980 through 1985 time period, the performance of defense-critical manufacturing industries was generally worse than overall manufacturing performance in the U.S. Only 41% of the defense-critical industry groupings matched or exceeded the overall manufacturing average growth in productive capacity. In real shipments, 75% achieved worse-than-average growth. About two-thirds had lower-than-average capital expenditures and the trend worsened during the 5-year period; 47% had below average productivity growth. Some industries actually experienced real declines in productivity. Most importantly, the worst performers were overwhelmingly subtier industries (non-systems suppliers). It is also important to note that the DoD accounted for a small fraction of the actual sales for many of the worst performers. This suggests that DoD initiatives alone may be insufficient to improve the conditions which exist in certain industry areas.

A recent U.S. Chamber of Commerce survey of 10,000 contractors regarding federal government procurement policy provided additional insight. Of the 1,100 respondents, 89% of which were businesses with fewer than 500 employees, 67% experienced flat or declining profits on their federal government work over the past 5 years. Of those surveyed, 55% stated that the projected returns on government business were not adequate to justify future investment. The primary reasons cited for decreasing future investment were reduced margins and financing pressures due to such policies as reduced progress payments.

The presentations given by a number of industry delegations helped to identify three specific factors which make return on government contracting unattractive given the risk involved. First, government contracting can severely strain the financial resources of a subcontractor. Changes in profit policy, reduced progress payments (if available), cost sharing, the cost of complying with government regulations, and increased competition were some of the perceived problems which reduce both cash flow and profitability. Analysis of these policy actions have shown a severe negative impact on industry returns (see MAC, LMI studies). Declines in cash flow posed a particular problem for the subtiers, especially small, entrepreneurial firms, since they are often thinly capitalized. Their access to additional financing is often much more limited than that of prime contractors. In addition, when more funding can be arranged, it is often at substantially higher interest rates than larger firms could negotiate. Obviously, anything which reduces profits compounds the problem. Reduced profits increase credit risk and limit a firm's capability to reinvest for the future. It appears that the minimum cost of doing business with the government may exceed the capabilities of some small, yet otherwise qualified subtier companies.

Second, and perhaps more importantly, proprietary data rights were critical to the well being of many businesses. Often, subtier businesses have developed their competitive advantage in specialized products or technologies. This is particularly true of very small, young companies which may only have one technological idea or product. When the foundation for that competitive edge -- proprietary data or knowledge -- is stripped away, the entire business may be severely damaged. Consequently, there are a number of companies, primarily small, which refuse to do business with the DoD because of the potential loss of intellectual property. Some medium to large firms actually segment their operations to erect walls to prevent the outflow of intellectual property to the DoD and often on to the public domain or competitors.

Software rights were identified as a special case where rights require a different treatment. The DoD has historically viewed software as the same as technical data. Software though, has a function, form and purpose which differs from technical data. Technical data is produced as an aid in the process leading up to the production of an item. In contrast, software itself is a unique product requiring significant R&D and often capital investment. It continually evolves and changes over time. Obviously, the demand for unlimited rights without adequate compensation serves as a strong disincentive to innovation and investment. As a result, companies working on DoD software may not invest heavily or use the best software development technology methods. Given the unique nature of software, some new balancing of government and private interests appears to be required to achieve desired results.

While the current DoD data rights policy is a step in the right direction, it still is deficient regarding technical data rights and essentially ignores the special and critical core of software data rights.

Finally, subcontractors perceived that primes sometimes force a greater amount of cost and risk down to the subtiers than they themselves are asked to bear by the government. In some cases, this is intentional but in other cases, it is due to an unnecessary automatic flowdown of contractual requirements.

A unique example of how the primes can affect the subtiers is foreign offsets demanded by foreign customers for in-country jobs and technology transfer. The subtier contractors contend that prime contractors often satisfy their offset requirements by using the subcontractor's work for offset. Not only do such offsets result in reduced subtier profitability and cash flow, but they may also require the transfer of data to a future competitor. Primes are generally not eager for offset yet view it in the context of "the only thing worse is the loss of a big foreign sale."

In short, the subtier sees itself as a higher risk and in a more difficult profit and cash flow position than prime contractors. In addition, the subtier faces generally more critical problems of data rights. Second sourcing or offset giveaways could result in their key technologies or products being transferred to a competitor.

A matrix approach (Figure VII-1) was useful in summarizing and highlighting the differential impact of recent changes in acquisition policies between industry tiers. While the list of acquisition issues utilized is not all inclusive, the Subgroup believes they accurately represent the major items which could affect subtier suppliers.

Legend  
 1=Limited Impact  
 2=Moderate Impact  
 3=Significant Impact

	Capped R&D and S&P	Fixed Price Development	Cost Shared Development	Lower Cost Recovery	Profit of Specs	Greater Govt Oversight	Reduced Progress Payments	Premature Pricing of Production Option	Special Tooling and Test Equipment	Increased Compensation	Forced Teamwork and Procurement	Second Sourcing	Spare Parts Breakout	Loss of Data Rights	Increase Offset Requirement
Prime Contractors	1	3	2	1	2	3	3	2	2	3	2	1	1	1	1
Subtier															
Large Firm (Independent or owned by large firm)	2	3	3	2	2	2	2	3	2	2	3	3	3	2	2
Small Independent Firm	1	2	3	3	3	1	1	1	2	1	3	3	3	3	1

Figure VII-1. Situation Matrix

As a result of the information reviewed, the Subgroup identified some areas which are general in nature that could, if corrected, improve DoD's management of subtier issues. Heightened direct communication between DoD and the subtiers, not only when policy making is underway, but also on a continuing basis, is critical if subtier conditions and concerns are to be understood by DoD. Prime contractors cannot, nor should they be expected to, represent the best interests of the subcontractors. There is a need for accurate and adequate data regarding both subcontractors and critical industry sectors. The DoD currently has neither the financial resources nor the data necessary to identify, prioritize and solve problems in subtier industries where its overall influence is limited. The bearing, optics and semiconductor industries are cases in point. While innovative DoD programs to support research and development or production improvements are helpful, they are simply not large enough to alter basic industry conditions. Given this situation, the DoD is faced with a dilemma -- it is responsible for national security, but does not have the capability to ensure that adequate industrial capabilities exist in the specific areas required. More involvement in the coordination of national economic and industrial policy appears to be a possible solution. Also, innovative solutions, which can be influenced by the DoD, such as pilot programs or tests, should also be encouraged.

Findings:

The overall conclusions of the subgroup regarding subtier effects are as follows:

- 1) The potential loss of data rights, either directly or through forced teaming or offsets, is the most significant problem facing the subtier. The loss of proprietary knowledge, without reasonable compensation, is leading subtier contractors to perform more work on their own to maintain proprietary rights or avoid government work altogether. The policy for software data rights is especially deficient.
- 2) Policy changes which strain subtier financial resources are a particular problem. Policies such as cost shared development and the funding of special tooling and test equipment can be more onerous at the subtier level. While prime contractors simply pass on whatever they can, the subcontractors often have no such avenue to offload cost and risk.
- 3) Actions taken which reduce contractor profitability, such as increased competition, altered profit guidelines and lower cost recovery, further compound subtier problems. Since returns are no longer commensurate with risks, there is little incentive to invest in government-related activities.

Recommendations:

The specific policy recommendations of the subtier subgroup are as follows:

- 1) Support the DoD's revised data rights policy initiative currently open to comment. While it is a good step in the right direction, deficiencies still exist with regard to data rights of technical data. In addition, the policy fails to deal with software data rights. The policy should be revised expeditiously.
- 2) DoD should promote equitable risk sharing between primes and subcontractors by discouraging disproportionate flowdown of more contractual requirements.
- 3) DoD acquisition policy should encourage consideration of special cash flow needs of subcontractors.



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## VIII.

## The Maritime Industry

National security depends on adequate transport of materials in times of national emergency. Of all materials transported in support of U.S. deployed forces and to supply our allies, 95% must be moved by surface transportation. As an island nation, we are vitally dependent upon shipping for import of critical raw materials and a large variety of finished goods. There have been numerous studies that validate this point that national security depends on transportation. In this paper, maritime transportation is addressed specifically.

The maritime industry's ability to transport material in times of national emergency is inadequate. U.S. merchant shipping has been reduced to a level significantly below the minimum level required to support national security needs by any standards used. This remains true even if the shipping available from our allies is included. There are many reasons why a once capable and effective merchant marine has deteriorated and these are well documented elsewhere. For whatever reasons, it is clear that the maritime industry's ability to transport material in times of emergency is inadequate.

The primary focus on maritime requirements in support of national security objectives has heretofore been on NATO Europe; thus, the inadequacy described above is exacerbated by the emergent importance of the Pacific Rim. Factors contributing to the problem are the great distances in the Pacific rim, the lack of concentration of allies, and the further possibility that sea lift in both areas may be needed simultaneously.

Natural market forces and global economic trends are unlikely to improve the maritime transportation capabilities of the industry without U.S. Government action. The latest reports indicate only about 4% of U.S. imports are being transported in U.S. bottoms while Americans spend over \$4.1B annually for transportation of all imports in foreign bottoms which have financial support from their government. U.S. citizens are paying for the foreign subsidy indirectly while U.S. flag carriers are not competitive in world trade. There have been decades of subsidy, tax incentives and special legislation for U.S. flag carriers that failed to solve the problem. A new look and a new approach are needed. American free enterprise and free trade must be supplemented by government planning and financing. Natural economic forces alone will not work.

The industrial base needed must include the assured capacity to build, sustain, man, and repair an effective national maritime transportation system and to surge when national emergency demands. The transportation segment (merchant marine), including ships and ship operators, must be supported by a shipbuilding and ship repair segment of the industry in order to have the assured capacity needed for national security.

The principles stated above are corroborated by studies from numerous groups and commissions, the most recent being the Commission on Merchant Marine and Defense. The national security needs and the lack of assured capacity to meet them have been asserted over and over. While we believe this is a national security issue for which the DoD should take the lead, departments and agencies outside DoD must share responsibility. Solutions will require substantial resources, but the net cost to the citizens may not be unacceptable since the cost of failure to act would be a far greater burden in time of national emergency.

U.S. Government (USG) policies during recent years was to permit competition and normal acquisition policies to foster capital investment and expansion to meet industrial base needs for current capability and surge requirements. These policies have not prevented the trends toward less capacity that is so critical today. USG policy for decades has included numerous subsidy, tax incentive and regulatory measures. These measures have not begun to solve the problem and the industry continues to decline. It is time for a broad new look at our national security needs, at our options for solution of the problem, and for decisive action.

The U.S. maritime industry, shipping, shipbuilding, and ship repair, is not competitive on the world market. Trade restrictions, pricing and other actions have reduced world trade transportation in U.S. bottoms to a very small percentage from what was once a majority position. At the same time, U.S. shipbuilders are not competitive in the world shipbuilding market. Today, no commercial ship is under construction in a U.S. yard.

The Government must consider the public policy issues and act to establish policies that will provide and maintain the maritime segment of the industrial base. Industry sponsored productivity and efficiency effort to gain a more competitive position can help solve this problem. Congressional action, piece by piece, to help with financial incentives or regulations alone will not solve this problem. A comprehensive solution plan is needed and it must be based on the validated national security needs of the nation. Only the Executive Branch of Government can do the central planning needed and DoD should take the lead.

The U.S. Government action options which might be considered, individually or in combination, are:

- o Subsidy
- o User fees by regulations
- o Nationalization
- o Formulation of theatre sealift pools of ships funded from an allied infrastructure purse.

Neither the option to nationalize parts of the industry, possibly with GOCO, nor an allied infrastructure has been analyzed. However, the latter should be an essential element of any affordable strategy. There may be other options which should be considered as alternatives to subsidy of the free enterprise system.

Conclusions:

- 1) The deterioration of the maritime industrial base needs to be corrected soon as a priority national security issue.
- 2) The maritime industrial base is a national security problem that exceeds the reach of DoD alone, but one for which DoD must take the lead and obtain broad government support.
- 3) Productivity and efficiency improvements are necessary but not sufficient to create an assured capacity.
- 4) USG financing will be necessary to achieve an assured capacity.
- 5) Best opportunity to build and revitalize the maritime industry is to build and operate a number of ships.

Recommendations:

- 1) SECDEF should develop a policy and obtain necessary broad government support for solving the maritime problems by building on the Report of the Commission on Merchant Marine and Defense.
- 2) CJCS should examine national security needs and rationalize lift requirements and lift available for likely scenarios (initial and sustained).
- 3) CJCS should determine assured capacity required and characteristics thereof.

- 4) SECDEF should seek an Allied commitment to contribute to addressing the sealift shortfall.
- 5) USD(A) should establish oversight within DoD under the DSB recommended Industrial Policy Committee.
- 6) SECNAV should establish a national shipbuilding program to achieve and sustain a meaningful fraction of the assured capacity.
- 7) SECDEF should establish a funding base by setting the policy in a NSDD and assigning programming action on DoD.

## **IX.**

## **Terms of Reference**

ACQUISITION

15 MAR 1988

### **MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD**

**SUBJECT: Terms of Reference--Defense Science Board (DSB) Task Force on Defense Industrial and Technology Base**

You are requested to form a Defense Science Board 1988 Summer Study on the Defense Industrial and Technology Base. The objective of this DSB task force is to recommend a strategy and specific actions for the Government and industry to adopt that will ensure the defense industry is capable of providing the support required to fulfill our National Security Objectives. The objectives require the defense industry to be capable of providing the technologies essential to our competitive strategies, as well as surge production requirements during times of crisis.

By meeting these objectives the Department of Defense (DoD) should be able to maintain an industrial strategic plan as an analog to our military strategic plans. Thus, a focus of this effort should be to recommend the linkages between military operations, research and development and industrial base planning and to suggest a balance between short and long term prioritization of industrial base issues. One area of particular concern is the subtler and overall infrastructure industries necessary to support DoD prime contractors.

The task force should review actions taken since the 1980 DSB Summer Study on Industrial Responsiveness, including:

- Changes resulting from the DoD industrial preparedness planning, policy, and procedural studies,
- Studies performed by the Office of Technology Assessment, the Center for Strategic and International Studies, and the Federal Government,
- National Security Council interagency mobilization planning studies, and
- Federal and Congressional actions that have helped or adversely affected acquisition lead times, productivity, incentive for capital investment, and technological innovations.

The actions of these organizations can be useful to help define the problems, and offer a baseline from which the DSB

task force efforts can begin. The task force can focus its attention on means by which DoD can deal with the problems.

The task force should recommend procedures for effective utilization of DoD resources to ensure a defense industry capable of providing the support required to fulfill our National Security Objectives. The task force should address:

- The DoD position in a global manufacturing economy and our increased dependency on foreign sources for essential components and raw or finished materials,
- Erosion of the second and third tier domestic support industry,
- Shifting priorities that influence industry's total investment in productivity improvements and technology,
- The role of Government-owned, company-operated research, development, and manufacturing facilities,
- Increased channeling of independent research and development investments away from innovation to an effort to reduce technical risk in ongoing weapons programs,
- Statutory and policy changes in DoD acquisition strategy including procurement methods, contract financing, competition, and cost sharing, and
- Improved estimates and prioritization of desired sectoral capability,
- Analysis of industrial capability that anticipates future weaknesses,
- Impact on national security of industrial trends,
- Support of allies/friendly nations to reach desired production capability,
- Prioritizing shortfalls, and
- Stimulating private sector initiative, DoD/industry cooperative opportunities.

The products of this task force will be a briefing to the Secretary of Defense summarizing results and recommendations of the study, as well as a report which will provide a foundation for the Secretary's guidance to the Department of Defense and industry to better support National Security Objectives. Particular attention should be given to modern concerns including the time delays inherent to a production system, both the delays of incorporating technological advances into weapons

and the delays of transitioning from peacetime to wartime production rates. The report should provide specific recommendations for the implementation of proposed DoD policy and procedures, and the execution of complementary business strategies.

Under Secretary of Defense for Acquisition, will sponsor the task force, and Mr. Robert A. Fuhrman will serve as Chairman. Dr. Robert A. Krell will be the Executive Secretary, and Lieutenant Colonel A. J. Beauregard, USAF, will be the DSB Secretariat Representative. It is not anticipated that your inquiry will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code.





## X.

# Organizations and Individuals Providing Information

### Industry/Government Advisors and Consultants

Mr. Gerald K. Bankus  
Mr. Rudy DeLeon  
BGen John W. Douglass, USAF  
Dr. Craig Fields  
Mr. James Hall  
Mr. Rick Jarman  
Mr. Charles Kimzey

Mr. William Lindahl  
Mr. Burton Malkiel  
Mr. Robert C. McCormack  
Mr. William B. Montalto  
Mr. Joseph Muckerman  
Mr. Gordon Stewart  
Mr. Alexander Trowbridge

### Briefings Received (OSD)

Hon Frank C. Carlucci  
Hon Robert B. Costello  
Hon Fred Ikle  
Hon Robert C. Duncan  
Hon Jack Katzen

Ms. Eleanor R. Spector  
Mr. Robert C. McCormack  
Dr. Craig Fields  
Mr. Charles Kimzey  
Mr. Richard Donnelly

### (Services)

Mr. James Corwin, USA  
Gen Donald Keith, USA (Ret)  
VAdm Robert C. Gooding, USN (Ret)  
Gen Lawrence A. Skantze, USAF (Ret)  
Hon Jay R. Sculley, USA

Hon Larry Garrett, USN  
Hon John J. Welch, USAF  
BGen William Hallin, OJCS  
RAdm Kenneth Malley, USN

### (Other Federal Agencies)

Mr. Allan Shaw  
OTA

Mr. Alan Cameron  
Commission on Merchant  
Marine and Defense

Mr. Paul Krueger  
FEMA

Mr. John Richards  
Department of Commerce

Mr. James Miskell  
NSC

Dr. John Brown  
Los Alamos National Lab

Dr. James Davis  
DOE

Dr. T. Weber  
Sandia National Lab

Dr. Charles Gilbert  
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**Dr. Siegfried Hecker**  
Lawrence Livermore National Lab

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**Mr. Bruce Scott**  
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**Dr. Myron Myers**  
Logistics Management Inst.

**Dr. Robert Anthony**  
Harvard

**Mr. Patrick Hawk**  
General Dynamics

**Dr. George Lodge**  
Harvard

**Dr. Jacques Gansler**  
TASC

**Mr. John Deutch**  
MIT

**Mr. Michael Rich**  
RAND Corporation

**Dr. S. Dertouzos**  
MIT

**Mr. David Koonce**  
Martin Marietta

**Dr. Anita K. Jones**  
University of Virginia

**Dr. Sonny Pierce**  
General Electric

**Mr. Philip Crosby**  
Crosby Association

**Mr. Charles Kuintzle**  
TEXTRON

**Mr. Leonard Sullivan**  
SAIC

**Mr. Mark Woolley**  
TEXTRON

**Mr. Vincent Cook**  
IBM

**Mr. Charles Albo**  
HEXSTAR Corporation

**Mr. Philip Farmer**  
Harris Corporation

**Mr. Dale Sullivan**  
IBM

**(Associations)**

**Mr. James Peterman**  
SEMATECH Executive Comm.

**Mr. John Swihart**  
AIA Technical Council

**Mr. George Kuper**  
National Academy of Science

**Ms. Lorraine Lavet**  
U.S. Chamber of Commerce

**Mr. Daniel Burton**  
Council on Competitiveness

**Mr. William Johnson**  
American League for Export  
Security Assistance

**(Congressional)**

**Mr. Gerald K. Bankus**  
SASC Staff

**Mr. William Montalto**  
U.S. Senate Small Business  
Committee Staff

**Mr. Rudy DeLeon**  
HASC Staff

**Note:** Many other organizations and individuals were interviewed  
by the Subgroups.



## XI.

## Glossary

**Acquisition Activity** - The organizational element of a Military Department that has contracting authority and responsibility and, therefore, the industrial preparedness planning responsibility.

**Advanced Development (6.3A and B)** - Programs which have begun development of hardware for test. Purpose of efforts in this category relate primarily to "proof of design" rather than development of hardware for use. All programs in the advanced technology development budget activity, and some programs in the strategic, tactical, intelligence and communications, and defense-wide mission support budget activities, are in the advanced development research category. Advanced development programs move from advanced technology development into the strategic, tactical, intelligence and communications or defense-wide mission support activity after they have been selected by the Defense Acquisition Board as programs which are to move from advanced development to engineering development, and eventually to production. This selection, known as a "Milestone I decision," takes place during advanced development.

**Advanced Technology Development (6.3A)** - Programs which explore "alternatives and concepts prior to development of specific weapons systems." Includes development of hardware and feasibility demonstrations for technologies which "are not formally identified to specific operational requirements." All advanced technology development programs are in the advanced development research category.

**Applied Research** - Research concerned with the practical application of knowledge, material, and/or techniques directed toward a solution to an existent or anticipated military requirement.

**Basic Research** - Research directed toward the increase of knowledge, the primary aim being a greater knowledge or understanding of the subject.

**Bid and Proposal (B&P) Costs** - Those costs incurred in preparing, submitting, and supporting proposals on potential contracts.

**Competition** - Government procurement actions and acquisition policy which intends for more than one contractor to bid for specific DoD proposals. It has become the prevalent strategy of the government in its efforts to reduce defense procurement costs and, in too many cases, is based entirely on price without regard to quality.

**Defense Guidance (DG)** - The document containing the annual guidance from the Secretary of Defense to DoD components.

**D-Day** - The day on which an operation commences or is due to commence. This may be the commencement of hostilities or any other operation.

**Engineering Development (6.4)** - Programs which develop hardware for military use according to specifications established by the services. Excludes development of systems already approved for production. Programs move from advanced development to engineering development when they are selected in a "Milestone II decision" by the Defense Acquisition Board. Engineering development programs are found in the strategic, tactical, intelligence and communications, and defense-wide mission support budget activities.

**Exploratory Development (6.2)** - Efforts directed toward evaluating the feasibility of proposed solutions to specific military problems. Includes both applied research and the development of "bread-board hardware." All exploratory development programs are included in the technology base budget activity.

**Incentives** - Those initiatives and policies adopted by government which encourage industry investment to create and maintain a modernized, competitive, productive and responsive industrial and technology base.

**Independent Research and Development (IR&D)** - A contractors' cost that is not sponsored by, or required in performance of a contract and that consists of projects falling within the following areas: 1) basic research, 2) applied research, 3) development, and 4) system and concept formulation studies.

**Investment Costs** - Those program costs required beyond the development phase to introduce a new capability into operational use, to procure initial, additional, or replacement equipment for operational forces; or to provide for major modifications of an existing capability. They exclude research, development, test and evaluation, personnel, and operation and maintenance costs.

**Management and Support (6.5)** - "Includes research and development efforts directed toward support of installations or operations required for general research and development use. Included would be test ranges, military construction, maintenance support of laboratories, operations and maintenance of test aircraft and ships and studies and analyses in support of the R&D program." All management and support programs are in the defense-wide mission support research activity.

**Mobilization** - The act of preparing for war utilizing the full authorities available under declared national emergencies.

**Operational Systems Development** - R&D on projects which are still in engineering development, but have already been approved for production by the Defense Acquisition Board in a "Milestone III decision." Operational systems development programs are found in the strategic, tactical, intelligence and communications, and defense-wide mission support budget activities. They are not included in Defense Department's R&D mission, but in the other missions (strategic, general purpose forces, airlift and sealift) as appropriate.

**Procurement** - The process of obtaining personnel, supplies, services, and equipment.

**Production** - The conversion of raw materials into products and/or components through a series of manufacturing processes. It includes functions of production engineering, controlling, quality assurance, and the determination of resources requirements.

**Production Base** - The total national industrial production capacity available for the manufacture of items to meet material requirements.

**Program Decision Memoranda (PDM)** - Convey the Secretary of Defense's decisions to the Services and Defense Agencies on issues raised during the programming and budgeting process. PDMs are the final major documents in the budget submission process.

**Program Objective Memoranda (POM)** - Provide total service programs and associated budget data necessary to support Defense Guidance objectives. The POMs detail manpower, material, and money for proposed programs as well as potential risk.

**P-Day** - The point in time at which the rate of production of an item available for military consumption equals the rate at which the item is required by the armed forces.

understanding in those fields of the physical, engineering, environmental and life sciences related to long-term national security needs." All "research" programs are included in the technology base budget activity.

**Surge** - Rapid increase, upon short notice, of the availability of material at the point of conflict, with or without a declaration of war.

**Technology Base** - Programs whose primary purpose is to improve scientific knowledge which can be adapted to military purposes. The "research" and "exploratory development" research categories are included in technology base budget activity.

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## XII.

## Bibliography

### Articles

- \_\_\_\_\_, "Clipped Wings," *Personal Investor*, July 1988.
- \_\_\_\_\_, "MIT Study Outlines Some Causes of Lagging Productivity in U.S.," *Investor's Daily*, February 17, 1988.
- \_\_\_\_\_, "World Military and Social Expenditures 1987-88," *World Priorities*, Washington, DC, 1987.
- Burgess, John, "As Foreign Investment Increases, So Do Concerns About Its Impact," *The Washington Post*, February 21, 1988.
- Carlucci, Frank, "Setting Priorities for the Nation's Defense," statement before the Senate Appropriations Defense Subcommittee, *Defense Issues*, May 10, 1988, Vol. 3, No. 29.
- Collis, David J., "The Machine Tool Industry and Industrial Policy, 1955-1982," *International Competitiveness, Reprint Series*, 1988, pp. 75-114.
- Commission on Engineering and Technical Systems, "Manufacturing Technology: Cornerstone of a Renewed Defense Industrial Base," Committee on the Role of Our Manufacturing Technology Program in the Defense Industrial Base, National Academy Press, 1987.
- Commission on Merchant Marine and Defense, Second Report, Recommendations, December 1987.
- Costello, Dr. Robert, "Initiatives to Improve the Acquisition Process" (Speech), *Army Research, Development and Acquisition Bulletin*, July-Aug. 1987.
- Defense Science Board 1981 Summer Study Panel on Technology Base, Office of the Under-Secretary of Defense for Research and Engineering, November 1981.
- Englund, Jon, "The Doctrine of Competitive Strategies," *Strategic Review*, Summer 1987.
- Friedman, Norman, "The Maritime Strategy and the Design of the U.S. Fleet," *Comparative Strategy*, Vol. 6, No. 4, 1987.

Gansler, Jacques S., "Needed: A U.S. Defense Industrial Strategy," *International Security*, Fall 1987.

Gladwell, Malcolm, "Are Defense Contracts Worth Cheating For?" *The Washington Post*, July 10, 1988.

Lamm, David V., "Why Firms Refuse DoD Business: Analysis of Rationale," *National Contract Management Association Journal*, Winter 1988.

Muckerman, Joseph, and Ralph Sanders, "A Strategic Rationale for Mobilization," *Strategic Review*, Vol. XII, No. 3, Summer 1984.

Oakar, Mary Rose, "Introduction of the Defense Production Act Amendments of 1988," Statement of Rep. Oakar as Chair, Subcommittee on Economic Stabilization.

Pescatore, Albert V., "Corporate Self-Governance: Development of Voluntary Disclosure Policy and Initial Results," *Contract Management*, May 1988.

Peterson, LTC Blair A., "The Defense Industry: An Illusion of a Free Market," *National Contract Management Association Journal*, Winter 1987.

President's Council on Management Improvement, "Government Excellence through Partnership," Summary of 1987 Annual Report to the President.

Stodden, John, "Harsher Contract Terms Erode U.S. Industrial Base," *Aviation Week and Space Technology*, January 4, 1988.

U.S. General Accounting Office, "Assessing Production Capabilities and Constraints in the Defense Industrial Base," Report to the Subcommittee on International Trade, Finance and Security Economics of the Joint Economic Committee, April 4, 1985.

Victor, Kirk, "Shooting Back," *National Journal*, May 21, 1988.

#### Defense Industry Publications

Ad Hoc Industry Advisor Committee, "Report to the Subcommittee on Defense Industry and Technology, Senate Armed Services Committee," February 5, 1988.

Aerospace Industries Association, Electronic Industries Association, and National Security Industrial Association, "Technical Paper on Independent Research and Development and Bid and Proposal Efforts," Washington, DC, March 1974.

Aerospace Industries Association, "Key Technologies for the 1990s -- An Overview," Washington, DC, November 1987.

Aerospace Industries Association, "Research and Development -- A Foundation for Innovation and Economic Growth," Washington, DC, September 1980.

Aerospace Industries Association, "The U.S. Aerospace Industry and the Trend Toward Internationalization," Washington, DC, March 1988.

Anders, William A., "Potential Impact of Some New Acquisition Initiatives on Aerospace/Defense Contractors," December 1986.

#### Federal Government Publications

\_\_\_\_\_, "Soviet Military Power: An Assessment of the Threat -- 1988," U.S. Government Printing Office, Washington, DC, 1988.

Augustine, Norman, Defense Task Force on Defense Semiconductor Dependency, OUSDA, February 1987.

Bement, Arden, Report of the DoD Laboratory Management Task Force, July 1980.

Bennett, Ivan, Defense Science Board Task Force on University Responsiveness to National Security Requirements, January 1982.

Carlucci, Frank C., "Annual Report to the Congress -- Fiscal Year 1989," U.S. Government Printing Office, Washington, DC, February 11, 1988.

Carlucci, Frank C., "The DoD Statement on Multiyear Procurement and Improving the Acquisition Process -- Testimony before the Subcommittee on Readiness of the House Committee on Armed Services," Washington, DC, April 29, 1981.

Commission on Integrated Long Term Strategy, "Discriminate Deterrence," U.S. Government Printing Office, Washington, DC, January 1988.

Commission on Merchant Marine and Defense, "Findings of Fact and Conclusions, First Report," Washington, DC, September 30, 1987.

DeLauer, Richard, Defense Science Board Acquisition Cycle Task Force Report, March 1978.

Department of Commerce, "Foreign Direct Investment in the United States -- 1985 Transactions," U.S. Department of Commerce, International Trade Administration, Washington, DC, September 1986.

Department of Commerce, "Foreign Direct Investment in the United States -- 1986 Transactions," U.S. Department of Commerce, International Trade Administration, Washington, DC, September 1987.

Department of Commerce, "Foreign Direct Investment in the United States: Completed Transactions, 1974-1983," Vol. I, II and III, U.S. Department of Commerce, International Trade Administration, Washington, DC, June 1985.

Department of Commerce, "Defense Market Brief," U.S. Department of Commerce, Office of Business Analysis, Washington, DC, April 1988.

Department of Defense, "Final Report of the Task Force on Acquisition Improvement," Department of Defense, Washington, DC, 1982.

Department of Defense, "Improving the Defense Acquisition System and Reducing System Costs," Department of Defense, Washington, DC, March 30, 1981.

Department of Defense, "Industrial Responsiveness," Report of the Defense Science Board, 1980 Summer Study, Department of Defense, Washington, DC, January 1981.

Department of Defense, "Practical Functional Performance Requirements," Report of the Defense Science Board, 1985 Summer Study, Department of Defense, Washington, DC, March 31, 1986.

Department of Defense, "Technology Base Management," Report of the Defense Science Board, 1987 Summer Study, Department of Defense, Washington, DC, December 1987.

Deutch, John, Defense Science Board Study on Technology Base Management, OUSDA, December 1987.

Executive Office of the President, "Highlights of the President's FY 1989 Management Report," Office of Management and Budget, Washington, DC.

Heilmeier, George, Defense Science Board 1981 Summer Study Panel on Technology Base, ODUSDRE (R&AT), November 1981.

Herman, Robert, USDRE Independent Review of DoD, USDRE, March 1982.

Institutional Barriers on DoD Laboratories, Senior Service Laboratory Representatives, October 1979.

Key Technologies for the 1990s, Aerospace Industries Association of America, November 1987.

Mobilization Concepts Development Center, Institute for National Strategic Studies, "U.S. Industrial Base Dependency/Vulnerability, Phase I and II," National Defense University, Ft. Lesley J. McNair, Washington, DC, December 1986.

National Science Foundation, "National Patterns of Science and Technology Resources, 1984," U.S. Government Printing Office, Washington, DC, February 1984.

Packard, David, Federal Laboratory Review Panel, White House Science Council, May 1983.

Project Forecast II, Final Report (SECRET), Air Force Systems Command, AFSCR/TR-86-005, June 1986.

Report of the Task Force for Improved Coordination of Science and Technology Programs, Institute for Defense Analyses, June 24, 1988.

Rich, Michael, et al., "Improving the Military Acquisition Process," RAND Corporation, Santa Monica, CA, February 1986.

The Defense Technology Base: Introduction and Overview, OTA, March 1988.

U.S. General Accounting Office, "Overview of the Status of the Defense Industrial Base and DoD's Industrial Preparedness Planning," Washington, DC, May 23, 1985.

U.S. General Accounting Office, "Status of the Defense Acquisition Improvement Program's 33 Initiatives," Washington, DC, September 1986.

White House, The, "National Security Strategy of the United States," Washington, DC, January 1988.

Other Publications

- \_\_\_\_\_, "Industry Looks at the U.S.'s Ability to Surge," Defense Management Journal, Second Quarter 1985.
- \_\_\_\_\_, "Last Chance for U.S. Shipbuilders," Sea Power, December 1984.
- \_\_\_\_\_, "Paper Rules Swell Cost of Defense," Los Angeles Times, May 21, 1988.
- \_\_\_\_\_, "The Engineering Research Centers: Leaders in Change," National Academy Press, Washington, D.C. 1987.
- \_\_\_\_\_, "The Impact of Defense Spending on Nondefense Engineering Labor Markets," a Report to the National Academy of Engineering, National Academy Press, 1986.
- American Society for Engineering Education, "A National Action Agenda for Engineering Education," Washington, DC, 1987.
- Anchordoguy, Marie, "The State and the Market: Industrial Policy Towards Japan's Computer Industry," Harvard Business School, January 1987.
- Center for Strategic and International Studies, "National Security Choices for the Next President," CSIS, Washington, DC, 1988.
- Dornbusch, Rüdiger, et al., "The Case for Manufacturing in America's Future," Eastman Kodak Company, Rochester, NY, 1988.
- Duga, Dr. Jules J., and W. Halder Fisher, "Probable Levels of R&D Expenditures in 1988 -- Forecast and Analysis," December 1987.
- Ethics Resource Center, Inc., "Defense Industry Initiatives of Business Ethics and Conduct -- Public Accountability," January 1988.
- Golden, William T., ed., Science and Technology Advice to the President, Congress and Judiciary, Pergamon Press, Elmsford, NY, 1988.
- Johnson, Joel L., "The Offset Issue: An Industry Perspective," Statement of Mr. Johnson, V. Pres., The American League for Exports and Security Assistance, before the House Committee on Foreign Affairs, Subcommittee on Arms Control, International Security and Science and the Subcommittee on International Economic Policy and Trade, June 24, 1987.

Lichtenberg, Frank R., "Government Subsidies to Private Military R&D Investment: DoD's IR&D Policy," Columbia University Graduate School of Business, January 1988.

Lichtenberg, Frank R., "The Duration and Intensity of Investment in Independent Research and Development Projects," Journal of Economic and Social Measurement, 1986.

Lichtenberg, Frank R., "The Private R&D Investment Response to Federal Design and Technical Competitions," n.d., n.p.

Logistics Management Institute, "Identifying Industrial Base Deficiencies," Bethesda, MD, December 1987.

National Academy of Engineering, "Focus on the Future: A National Action Plan for Career-Long Education for Engineers," NAE, Washington, DC, 1988.

Packard Commission, "A Report to the President by the President's Blue Ribbon Commission on Defense Management," June 1986.

Pfaltzgraff, Robert L., ed., The U.S. Defense Mobilization Infrastructure, Archon Books, 1983.

RAND National Defense Research Institute, A Preliminary Perspective on Regulatory Activities and Effects in Weapons Acquisition, The RAND Corporation, Santa Monica, CA, March 1988.

Samuelson, Pamela, "Proposal for a New 'Rights in Software' Clause for Software Acquisitions by the Department of Defense," Software Engineering Institute, Carnegie Mellon University, September 1986.

Shipbuilder's Council of America, "Revitalization of the U.S. Shipbuilding Mobilization Base," 1988.

